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NewScientist

WEEKLY February 7 - 13, 2015

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bites the dust

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The new Audi A3 Sportback e-tron.



WHATCAR?

Car of the Year 2015

Best electric car

weighted: 176.6 mpg (1.6 litre/100km). CO₂ emissions: 37g/km. The 'Combined/weighted' fuel consumption CO₂ figures calculated from two taking into account mileage range on battery power only, providing a figure in a variety of charge conditions. Extended range achieved by 1.4 TFSI real driving results. Images for illustration purposes.

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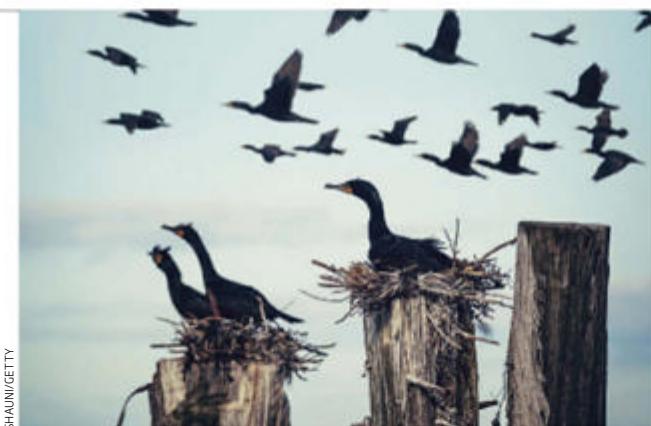


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SHAUNI/GETTY

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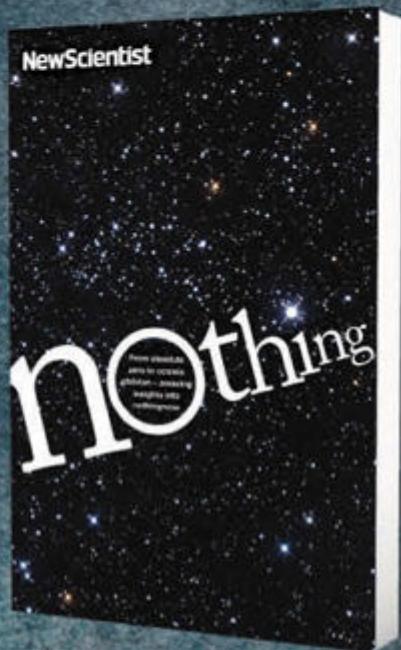
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Loving the algorithms

We don't need to understand how they work to live with them

WHAT is an algorithm? Ask a coder or a mathematician, and they will tell you it is basically a recipe – a step-by-step list of instructions. Innocent enough. But to some, the term has begun to sound quite sinister.

Algorithms are everywhere. They decide what results you see in an internet search, and what adverts appear next to them. They choose which friends you hear from on social networks. They fix prices for air tickets and home loans. They may decide if you're a valid target for the intelligence services. They may even decide if you have the right to vote.

Much of this goes unremarked by those it affects. But when people become aware of it, the reaction is apt to be hostile – as it was last year when news broke that Facebook had experimented with manipulating its users' emotions through minor changes to their newsfeeds.

This mistrust isn't helped by the baffling, often absurd results when algorithms don't work as anticipated. Minor goofs, from odd translations to eccentric suggestions, are popular when shared on social media. But bigger glitches can have serious consequences, from "flash crashes" on stock markets to fire sales on shopping sites.

And as algorithmic systems grow more tangible, concern is mounting that they are getting too powerful. An offbeat web ad is one thing; a driverless car that ploughs through a playground is another. These systems don't even have to malfunction to provoke unease: their decisions can run counter to our ideas of fairness. Algorithms don't see humans the same way other humans do.

"The benefits of algorithms may be inseparable from their side effects – as with the Industrial Revolution"

Put it all together, and the image that comes to mind is of HAL 9000, the inscrutably murderous supercomputer in *2001: A Space Odyssey*, and its impassive, unblinking red eye. (The AL in HAL is a contraction of algorithmic, after all.)

No wonder that some people are now trying to check whether algorithms are working as their creators intended. Few of these self-appointed auditors have inside access: rather, they're judging algorithms by the results they produce (see page 30).

Some argue that we need something akin to the regulators that oversee financial services and utilities. Perhaps. But what

would such watchdogs do? Vetting algorithms in advance isn't practical: many are too complex for their outputs to be predicted.

We could start by recalling that algorithms don't do anything themselves: they are just recipes. The doing is by systems built to act on their suggestions, often without human intervention.

So a watchdog could specify the kinds of actions that require humans in the loop. It could also act on the "clickwrap" agreements that covertly give the creators of such systems licence to make free with our data – and crack down on government and public services that assume our consent. This is not dissimilar to the intent of the information commissioners some countries have – although the practice would have to be quite different if it is not to hamstring algorithmic systems' ability to deliver real and sizeable benefits.

Ultimately, those benefits may prove inseparable from their unfamiliar side effects. But then, much the same could have been said of the machines introduced during the Industrial Revolution. Most of us don't understand how descendants of those machines bring us modern life, and we may never really grasp the alienness of algorithms. But that doesn't mean we can't learn to live with them. ■

Yes to three parents

IN AN outbreak of scientific enlightenment among politicians, UK members of parliament have voted to allow mitochondrial donation. A vote on Tuesday passed with 382 in favour and 128 against.

The procedure will allow women with genetic faults in their mitochondria - the cell's energy generators - to have children without fear of passing on their faulty mitochondrial DNA. It involves transferring the nucleus of the mother's egg or fertilised embryo into an egg from an unrelated donor. The resulting child will inherit its nuclear DNA from its parents and its mitochondrial DNA from the donor.

In the debate prior to the vote, health minister Jane Ellison told parliament: "This is a bold step

but it's an informed step, and for the families involved it's a light at the end of a very long tunnel."

The opposition's shadow health minister Luciana Berger also threw her weight behind the procedure. "There will always have to be a leap of faith the first time it's used in humans," she said.

One potential beneficiary is Hannah Smith, a 27-year-old woman from Measham in England. She has MELAS syndrome, a condition in which a mitochondrial genetic fault can result in diabetes, hearing loss and epilepsy. "I'm of a child-bearing age and it couldn't have come at a better time," Smith told *New Scientist*. "It means I can live a normal life, my children can live a normal life and their children can live a normal life."



New dimension for IVF

Vostok break-in

THEY'VE cracked it! A Russian team of ice explorers has broken through to a lake buried beneath nearly 4 kilometres of Antarctic ice. The lake has been isolated from the surface for 15 million years and could hold extreme forms of life never seen before, perhaps even offering clues as to what life on other planets might look like.

Lake Vostok is Antarctica's largest subglacial lake. It was reached once before in 2012, when a Russian team finished drilling a

"The lake has been isolated for 15 million years and could hold extreme forms of life never seen before"

hole some 3770 metres down to its surface. They claimed that water samples they obtained from this borehole contained DNA that was unlike known bacteria, suggesting they may have found an unusual native species. But the find is controversial, not least because the samples were contaminated with fluid used to aid drilling.

The second attempt reached the lake surface at 5.12 pm on 25 January. The team used the same borehole down to 3400 metres below the surface, after which the holes diverge. This time, the team says they proceeded with extreme caution and are confident that the new samples they retrieved are pristine lake water.

Using information on the lake's pressure and depth, collected in 2012, they calculated how slowly they needed to raise the drill to avoid a piston effect, whereby lake water suddenly surges upwards and mixes with drilling fluids, which is what happened last time.

The team was led by Vladimir Lipenkov of the Arctic and Antarctic Research Institute and Nikolay Vasiliev of the National Mineral Resources University, both in St Petersburg. They say that after penetrating the surface of the lake, the team let water rise in the borehole, where it froze. They then removed a core of this frozen lake water. "We hope to get these samples for analysis by the middle of May," says Lipenkov's colleague Irina Alekhina.

Robot car wars

SELF-DRIVING cars will soon *fahren auf der Autobahn*. Germany is drawing up laws to govern autonomous vehicles on the nation's motorways. Transport minister Alexander Dobrindt told *The Guardian* newspaper that the laws will cover what happens when computer-driven cars make a mistake that results in an accident, and how such cars should be licensed and insured.

Meanwhile, taxi-booking app

Uber announced a partnership with Carnegie Mellon University in Pittsburgh to create the Uber Advanced Technologies Center to research autonomous cars. Uber CEO Travis Kalanick is known to be bullish about self-driving cars, seeing them as a way to bring down the cost of the service.

At the same time, there are rumours that Google is readying its own car-booking service to compete with Uber's. Google has already safely tested autonomous driving prototypes over hundreds of thousands of kilometres.

Countdown to Europa

PACK your ice gear - we're going to Europa. NASA's budget request for 2016 includes \$30 million for a dedicated mission to Jupiter's icy moon, which is considered one of the best prospects for discovering life in our solar system.

"This is a big deal," says Robert Pappalardo at NASA's Jet Propulsion Lab in Pasadena, California, the pre-project scientist for the Europa Clipper probe concept. "We're moving toward the next phase, where you're

a real mission. It's just thrilling after 15 years of pushing for it."

NASA had already begun preliminary work on such a mission, but was missing a commitment to further funding. Now, it has requested \$255 million over the next five years, and plans to select science instruments this spring. The mission will probably involve a spacecraft orbiting Jupiter and making multiple fly-bys of Europa, rather than landing on or orbiting the moon itself.

60 SECONDS

Arctic drilling ban

DRILLING for oil in Alaska seems to be on thin ice. The White House proposed tougher environmental protections last week for almost 5 million hectares of the Arctic National Wildlife Refuge in

"The US is becoming more aware of its responsibilities. We're waking up a bit towards the Arctic"

Alaska, which it called "ecological treasure". It also announced plans to ban drilling in almost 4 million hectares off the Alaskan coast.

The moves show that the US is becoming more aware of its environmental responsibilities up north, says Malte Humpert at The Arctic Institute, a think tank in Washington DC. "We're waking up a little bit towards the Arctic."

Meanwhile, Shell said it was reviving plans to drill in Alaska's Chukchi Sea. The company had been forced to suspend operations in 2012 following a series of technical problems. The new move has alarmed environmentalists, who say that Shell is unprepared for a potential spill in the region.

"As we learn more and more of what Shell is planning this year, we're hoping the government takes a more cautious approach," says Leah Donahey of the Alaska Wilderness League, a non-profit organisation in Washington DC.

GREENPEACE/TOM JEFFERSON



Coal mines could threaten reefs

The reef election

THE Great Barrier Reef might emerge as the winner this week in an election in Queensland, Australia. Early indications are that voters have chosen to throw out the state government, which has been criticised for its attitude of "development at all costs".

The conservative Liberal National Party was voted to power in 2012 and has pledged to continue developing coal mines, which were linked to controversial

"If the opposition forms government, the reef has a far better chance of recovery"

port expansions that can harm the reef. "We were very disappointed in the policies of the previous government," says Nick Heath, Great Barrier Reef programme manager at WWF-Australia. "If those policies had continued, the reef's spiral of decline would be accelerated." The reef faces major threats from climate change, port development, shipping and surface run-off from agriculture.

The Labor opposition's pledges include a "save the reef" policy that would remove subsidies for coal mines in Queensland's Galilee Basin. This has led some to speculate that the mining would not go ahead, which could put a

stop to port expansion. Labor also said that, if elected, it will aim to reduce nutrient run-off from some major agricultural regions by 80 per cent in a decade and spend AU\$100 million to improve water quality. "Reefs cannot grow or recover in polluted water," says Heath. "If the opposition forms government, the reef has a far better chance of recovery."

Higher cancer risk

ONE in two. If you are under the age of 55, that's the likelihood you'll be diagnosed with cancer at some point in your life, according to projections in a study funded by Cancer Research UK. The estimate replaces the well-known one-in-three statistic for lifetime cancer risk, and reflects an increase in life expectancy.

The study analysed cancer cases in people born between 1930 and 1960. It found that a man born in 1960 has a 53.5 per cent risk of developing cancer during his lifetime, compared with 38.5 per cent for a man born in 1930. The researchers extrapolated this trend for people born since 1960, but the estimate may not be as scary as it sounds: it doesn't capture any changes in disease and lifestyle trends that may have occurred since (*British Journal of Cancer*, DOI: 10.1038/bjc.2014.606).

NASA/JPL-CALTECH/SETI INSTITUTE



Life under the ice?

Measles resurgence

This year is turning into a desperate one for measles in the US. An outbreak that started at Disneyland in California has now infected more than 100 people across 14 states. To stem the outbreak, schools have ordered unvaccinated children to stay at home, and President Barack Obama has urged parents to vaccinate their kids.

My own medicine

Personalised medicine just got a shot in the arm. The White House announced last week that \$215 million would be put aside in the 2016 budget to research the use of people's genetic profiles and lifestyle data to deliver better, more tailored medicine. Improving cancer treatment is the programme's first objective.

Urban cacophony

Struggle to make yourself heard in a noisy street? Take a tip from the black-capped chickadee and the American goldfinch. In areas with high traffic noise these birds raise the lower pitches of their calls, but their higher pitches remain unaltered. This could be because the lower tones are masked by traffic noise (*Ethology*, doi.org/zrb).

Dawn goes up

Iran state media reports the country has launched its fourth satellite, its first since 2012. Named Fajr, the Persian word for dawn, the satellite is the nation's first to be equipped with thrusters for orbital manoeuvres and has a camera to take pictures of Earth.

Engineering prize

Robert Langer of Massachusetts Institute of Technology has won the £1 million Queen Elizabeth Prize for Engineering. Langer's work on controlled drug delivery has provided the foundation for various disease treatments. He is now developing microchip implants for long-term controlled drug release.

India's lost daughters

Technology is making it easier for couples to limit the number of girls they have. The result, 6 million fewer girls born between 2001 and 2011

Debora MacKenzie, New Delhi

THE Republic Day parade in New Delhi last week was the first ever attended by a US president. The visit was hailed as recognition of India's growing geopolitical importance.

Besides the tanks and fighter jets, what the Obamas saw were women, including the country's first all-female marching battalions, a woman leading the honour guard and a re-enactment of Indian women conquering Everest in 1993. "Congratulations, it's a baby girl!" proclaimed a float.

The float celebrated Prime

Minister Narendra Modi's £10 million "Save the daughter" campaign, which aims to persuade Indian couples to stop selectively aborting female fetuses, a practice that some worry is already causing social instability in the country. Abortion is legal in India, but not on the basis of fetal sex.

Two days after the parade, India's highest court ordered the Google, Yahoo and Bing search engines to stop adverts for providers of prenatal sex determination from popping up alongside online searches for the procedure. Next week

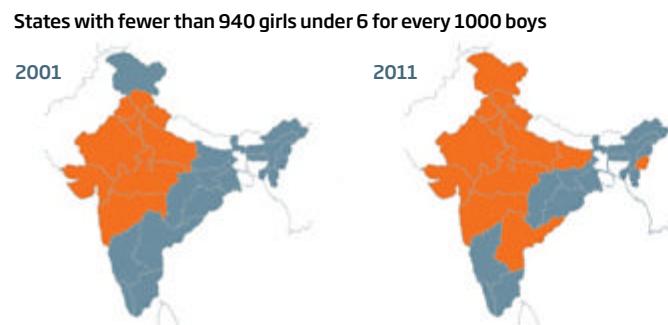
the court is expected to order them to block adverts in the search results themselves.

Girls have long had a hard time in India. Infanticide was historically common, especially in north and west India, as girls were expensive to keep and required a dowry, while it was the sons who supported ageing parents. This had waned by the 1950s, but in the 1970s parents began to switch to prenatal sex selection, thanks to the availability of tests such as amniocentesis, and abortion. This accelerated in the 1990s, says Arindam Nandi of the Public Health Foundation of India, when ultrasound became available.

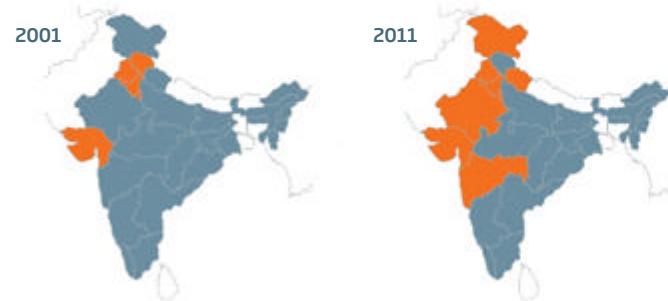
Using careful statistical analysis of the country's census data, Prabhat Jha of the University of

Non-existent girls

Many Indian states have a sex imbalance in favour of boys. This is most marked in the north-west



Fewer than 910 girls under 6 for every 1000 boys



"You can get access to sex-determining ultrasound in villages that don't have clean drinking water"

Toronto calculates that up to 4 million girls were aborted between 1991 and 2001, and a further 6 million by 2011. Most are aborted at five months – ultrasound at four months can detect the fetus's sex. This could become easier with the next generation of prenatal testing, which requires only a blood test.

The search providers involved in the recent court case protest that they already comply with India's advertising restrictions. "In India, we do not allow ads for the promotion of prenatal gender determination or preconception sex selection," a Google spokesperson told *New Scientist*.

Searching for "ultrasound



PIYAL ADHIKARY/EPA/CORBIS

"Delhi" in India led to a slew of ads for small clinics. None mention sex determination, but many have pictures of babies and offer other kinds of ultrasound tests. A search on "ivf boy Dubai" in New Delhi turned up adverts for clinics outside India that offer fetal sex tests and IVF babies of the desired sex. Both are illegal in India, but are increasingly the choice for the country's elite, says Sabu George of the Centre for Women's

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Standing up for unborn sisters

Development Studies in New Delhi, who filed the court case.

And you don't need access to the internet. "You can get an ultrasound in villages that don't have clean drinking water," says Nandi. Technicians use code to tell parents what they want to know: buy pink clothes, say. "Everyone knows which clinics will tell you," says George.

A look at the data from the 2001 and 2011 Indian censuses

shows what has happened (see maps, left). Normally, human societies have 950 girls for every 1000 boys aged 6 and under. For India, the number of girls per 1000 boys was 927 in 2001, and 914 in 2011. This seems a small effect but Jha says that in such a

People say they want balance in their families. But they don't abort second boys. Only girls"

populous country it equates to millions of aborted girls.

The practice is spreading. Skewed sex ratios are starting to show up in states such as Kerala, where female infanticide was not historically an issue but where ultrasound clinics are now common. "I fear it will be worse in 2021," says George, when the next census is due.

Like all modernising societies, India went from some six children per woman in the 1960s to 2.4 now. "In the past, people just had children until they had the desired number of boys," says Nandi. Now families planning only two children feel they cannot leave boys to chance.

Sex-linked IVF

Jha has found that in families where the firstborn was a girl, the second child was unnaturally likely to be a boy, with survey data from 1990 showing 906 firstborn girls per 1000 boys getting a little sister, and just 836 in 2005. If the firstborn was a boy, sex ratios among subsequent children were normal. "People say they just want balance in their families," he says. "But they don't abort second boys. Only second girls."

The effect was greater the more wealthy and educated the family was. Now, says George, affluent couples are having IVF in Dubai or Singapore and choosing male embryos. Advances in prenatal testing will also make things easier and earlier. The Beijing Genomics Institute in China, as well as several US-based firms, have tests that sequence fetal genes from the mother's blood in the first trimester.

The real issue, say George and other researchers, is one of human rights. But does a male-female imbalance also do social damage? An influential analysis in 2005 argued that societies with fewer girls and large numbers of unmarried men see more violence and instability. But some argue there is little evidence for this.

LOOKING FOR A WIFE

Whether India's sex imbalance is associated with more violence is debated. Either way, the situation is hurting both women and men.

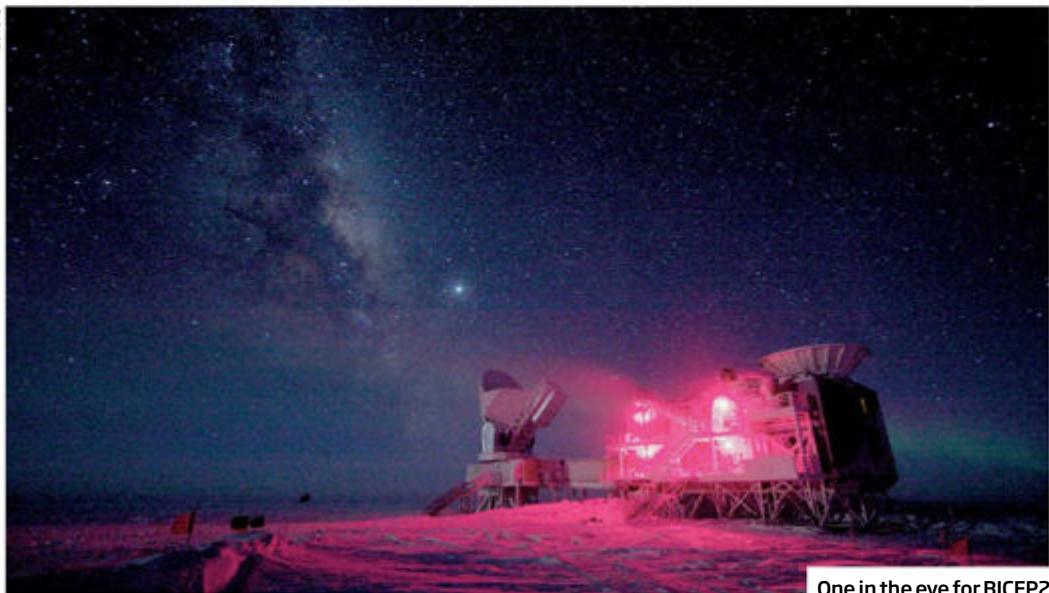
Two hours' drive from Delhi, where people farm sugar cane and mangoes, many say their region is becoming more violent. Its ramshackle market towns are full of clinics offering ultrasound. The area's last census showed a mere 835 girls under 6 per 1000 boys, down from 842 in 2001. I chat to a prosperous farming family that could be a pin-up for India's social changes: the mother is illiterate, the daughter is doing a PhD in education at a local college.

The father says there is too much violence against women. He agrees there are many more boys than girls - but insists this is just natural in the area.

A local contact introduces me to a family of five brothers. Only three have married; one did so by buying a wife, a woman widowed by India's deadly road traffic. In another household, another wife has been bought in. Neither spoke the local language on arrival; both are visibly depressed and scared to talk, and look more like servants than wives. One is five months pregnant, misses the daughter she left behind, and expects to be sterilised after this baby. She is 26.

In another house, one unmarried man seems to say his brother allows him to have sex with his wife. What the wife thinks of this can only be imagined.

In India, recent research has suggested increased violence against women goes along with excess men, though this might be explained by increased crime reporting (see "Looking for a wife", above). Either way, we need more studies of the impact of gender imbalance, says Sanjay Zodpey of the Public Health Foundation of India. "But we shouldn't wait to measure the impact before we stop this happening." ■



One in the eye for BICEP2

Big bang discovery crumbles to dust

Maggie McKee

IT WAS fun while it lasted. Last March, cosmologists celebrated what seemed like evidence that space-time had shaken violently during the big bang. The discovery of the apparent gravitational waves was hailed as the “smoking gun” for a theory that the infant universe experienced an epic growth spurt known as inflation. Physicists popped corks in elation and dreamed of a Nobel prize.

But 11 months later, this smoking gun has itself gone up in smoke, and researchers are nursing a hangover. “We are pretty much back to where we were before,” says Alan Guth of the Massachusetts Institute of Technology, who proposed the theory of inflation in 1981.

It all started on 17 March, when astronomers using a telescope called BICEP2 at the South Pole reported seeing telltale signs of gravitational waves in a tiny patch of sky viewed at a particular wavelength in the microwave

range. That was exciting because although inflation should have produced gravitational waves, there was no guarantee they would be strong enough to detect. There are hundreds of models of inflation, each with its own prediction about how fast the universe expanded – and therefore how powerful the resulting gravitational waves would be.

So it was even more astounding that the strength of BICEP2’s waves fitted the simplest version. In this model, inflation proceeded more or less like a ball rolling down the inside of a U-shaped bowl, with expansion starting fast then slowing down. “The simplest theory yields predicted gravitational waves right where BICEP2 seemed to see them,” says John Peacock at the University of Edinburgh in the UK.

But the excitement was short-lived. A series of studies soon suggested that dust within our galaxy may have muddied the picture. Observations at other

wavelengths were needed to clear up the confusion, as dust shines more brightly at certain wavelengths than at others.

In September, researchers used Europe’s Planck satellite to show that BICEP2’s entire signal could be due to dust (*Astronomy & Astrophysics*, doi.org/zt8). The final nail in the coffin came last week, when a study combining BICEP2 and Planck data showed that the dust observed with Planck lined up with the signal the BICEP2 team had attributed to gravitational waves. This all but rules out the simplest

“Planck showed BICEP2’s entire signal could be due to dust. The final nail in the coffin came last week”

model: if they are out there, any gravitational waves from inflation must have been no more than about half as strong as those seen with BICEP2, in line with the Planck team’s earlier estimates.

Upcoming observations will put more models to the test by improving measurements of possible contaminants. That means studying the sky with great sensitivity at a range of places and microwave wavelengths. “To claim a detection of a primordial

signal, one has to exclude the possibility, to the fullest extent possible, that something else hasn’t generated the signal,” says William Jones of Princeton University, who leads a balloon-borne mission called SPIDER that is expected to release its observations in a year or so.

Gravitational waves are not inflation’s only prediction. For example, ultra-fast expansion can explain how the universe, which could have started out with any curvature, came to appear so flat. But a rival theory, which says the universe cycles between periods of expansion and contraction, can also account for those mysteries, says Paul Steinhardt of Princeton, a pioneer of both inflation and its cyclic competitor.

The cyclic model predicts that we should not see any gravitational waves from the early universe, so BICEP2’s initial announcement seemed to deal it a fatal blow. Now, without a discovery of gravitational waves, the theory of inflation has lost its most powerful line of evidence. “The current non-detection certainly does not rule inflation out, but equally, without a detection, many, including me, would not consider the theory to be proved true,” says Peacock.

Steinhardt fears that inflation is so flexible it cannot be proved false. Once started, inflation is hard to stop, and should have spawned a zoo of universes, each with different properties. “Any result can fit somewhere in the multiverse,” Steinhardt says. Inflation’s simplest model barely fits the observations now, leaving only more complicated models still alive, he adds. “Shouldn’t that give some people pause?”

“It worries me,” admits Matias Zaldarriaga of the Institute for Advanced Study in Princeton, who helped figure out how to spot signs of gravitational waves nearly 20 years ago. But he adds: “Nature is how it wants to be. It doesn’t follow from any logic that the simpler thing is the true one.” ■

Ancient life helped form Earth's largest gold hoard

WHERE there's gold, there may have been life. Some of the oldest life forms may have played a key role in the formation of Earth's largest known gold reserve.

The process could only have taken place during a window of opportunity after life on land came into being and before the planet got its oxygen-rich atmosphere. This means such gold deposits could not be formed today – but it potentially gives us a new way to find them.

Witwatersrand basin in South Africa is the largest single source of gold – roughly half the gold ever mined comes from there. The metal accumulated in the basin 3 billion years ago, but how it did so is a matter of debate.

Gold first reached Earth's surface through the erosion of gold-bearing veins in a granite mountain range called the Kaapvaal Craton in what is now north-east South Africa. It came up with the lava that formed the mountains. But it is unclear how huge quantities of this gold then ended up several hundred

kilometres to the south-west in the Witwatersrand basin.

It was thought that fragments were eroded from the mountains, transported by rivers and dumped in shallow lakes overlying what is now the gold-rich basin.

But Christoph Heinrich of the Swiss Federal Institute of

"The billion-dollar question is whether the same process created other gold deposits"

Technology in Zurich disagrees. He argues that the gold was dissolved by volcanic rain and then washed to the basins by rivers. Here, mats of microbes growing in shallow pools converted it back into the solid element (*Nature Geoscience*, DOI: 10.1038/NGO2344).

Central to his theory is that 3 billion years ago, the atmosphere was still largely free of the oxygen that was produced half a billion years later by algae and cyanobacteria during the great oxygenation event. Before this event, the air was full of



Rich pickings, but how did it get here?

sulphur-rich gases – such as hydrogen sulphide – pumped out by volcanoes and rained down on the mountains, dissolving the gold.

This could not have happened once the air was full of oxygen because "oxygen would have 'killed' the sulphur compounds that carried the gold", says Heinrich. "We don't know if the gold precipitated out during the life of the microbes or after they died, but basic chemistry tells us that organic life reduces gold to its elemental form."

"The billion-dollar question is whether the same process created other gold deposits," he says. If it did, then it may offer geological clues for today's gold prospectors. Instead of focusing on gravel-rich areas, we should look at land-bound carbon-rich shale areas.

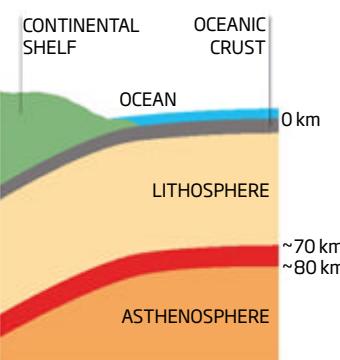
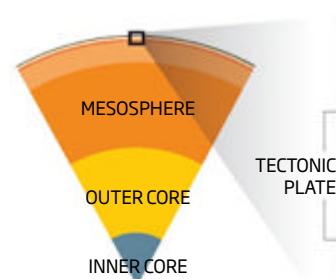
Heinrich's theory is worth serious consideration, says Jan Kramers of the University of Johannesburg in South Africa. "It works well with the observation that the atmosphere was not oxidising and the rain was more acidic than today." Andy Coghlan ■

Mini quakes reveal base of tectonic plates

KABOOM! Dynamite explosions have given us a detailed glimpse of a geological "lubricant" that aids the movement of Earth's tectonic plates. These plates interlock like a massive jigsaw to make up the planet's outer layer, or lithosphere, which is around 70–100 kilometres deep. Their movement can trigger earthquakes, so gaining a better idea of how they move may aid our understanding of tremors, according to Tim Stern of Victoria University in Wellington, New Zealand.

The plates sit atop a lubricating

An unprecedented view of the base of tectonic plates shows a narrow **lubricating layer** that allows them to move



channel that separates them from the asthenosphere underneath. "Tectonic lubrication is a valid description of what we think happens in this 10-kilometre-thick channel," says Stern. The lubricating layer contains

viscous melted rock that allows the plates to move independently of the layers below.

Stern and his colleagues directed explosions from Earth's surface down into a zone beneath New Zealand,

then captured reflections of the resulting seismic waves to build up images of the base of the tectonic plate (*Nature*, DOI: 10.1038/nature14146). Previous studies relied on distant, low-frequency seismic waves from real earthquakes, which dramatically limited the resolution. By setting off 12 of their own "mini earthquakes" with dynamite buried in 50-metre-deep shafts, Stern's team got much sharper images with a resolution of less than a kilometre.

"What's so cool is that they've really identified the base of the plate, showing it's shallower and sharper than previous observations," says Catherine Rychert of the University of Southampton in the UK. "No one has been able to image the channel before." Andy Coghlan ■

Best drug yet for endometriosis?

Helen Thomson

TWO new drugs are the first to treat endometriosis without harming fertility. The hope is that they will one day help the 10 per cent of women of reproductive age who suffer from the condition, which can cause infertility and chronic pain.

Endometriosis is a relatively common disorder in which cells that normally grow only in the uterus (see picture, orange triangle) travel into the abdominal cavity. There they form lesions and cysts, scarring organs such as the ovaries, fallopian tubes, bladder and rectum. These lesions also lead to inflammation and nerve growth, causing abdominal pain.

The condition causes infertility in up to 50 per cent of women who have it. Surgically removing lesions or cysts can temporarily relieve pain until they grow back, while a longer-term solution is to reduce levels of the hormone oestrogen. Like healthy endometrial tissue in the uterus, the lesions and cysts rely heavily on oestrogen to grow and survive, but reducing its level throughout

the body has unfortunate side effects, such as menopausal symptoms and infertility.

Women with endometriosis who want to have children may face a catch-22 situation – they need to treat the condition to conceive, but this hormonal treatment makes them infertile. Stop the treatment and fertility may return, but

so too do the lesions.

There might be a solution. Through a series of experiments, Benita Katzenellenbogen of the University of Illinois at Urbana-Champaign and her colleagues discovered that the oestrogen receptors in lesions are different from those found in normal reproductive tissue. The finding allowed the team to develop two drugs that only affect receptors in the wayward endometrial tissue.

When given to mice, the drugs – called chloroindazole and oxabicycloheptene sulfonate – reduced the size of

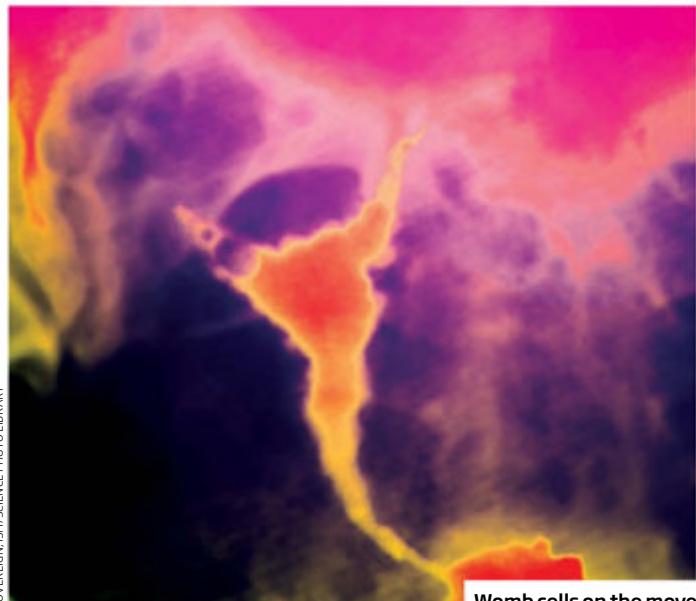
existing lesions and stopped the growth of new ones (*Science Translational Medicine*, doi.org/zqv). The team thinks the drugs work in part by interfering with inflammation pathways.

The compounds prevented the development of new nerves in the lesions and also decreased pain. Crucially, neither of them altered the rodents' fertility or the health of their pups.

The drugs also had a similar effect on human endometrial tissue taken from cysts that had been removed from patients. "We are hopeful that these compounds will prove to be useful for women with this common disease," says Katzenellenbogen, although she adds that it may be several years before human trials can start.

Christian Becker, a consultant gynaecologist and endometriosis specialist at the University of Oxford, says the research is encouraging. "It's good that this is getting some attention as it affects so many people, but it's not historically been a cool thing to talk about."

He says it would be good to avoid surgery if possible – he has seen women who have had to endure 10 rounds of keyhole surgery. "It's fascinating to see the drugs had very little effect on the [normal] endometrial tissue and the pups, but we have to wait to see whether this will hold up in humans." ■



but a small number are able to kill nematode worms and insects. The toxins they use potentially include the pleurotolysin protein produced by the carnivorous oyster mushroom (*Pleurotus ostreatus*), says Michelle Dunstone at Monash University, Australia.

Individual molecules of this protein can act like Lego bricks, linking together in rings of 13 on the surface of a target cell. They then unravel downwards, punching through the cell membrane like a nanoscopic cookie cutter, creating an 8-nanometre-wide hole and killing

the cell. These proteins are unusual in their ability to switch from a soluble, detached state to coming together on a cell's surface. "It's quite a dramatic change," says Helen Saibil at Birkbeck College in London.

Saibil – working with Dunstone and her colleagues – examined snapshots of the process at various stages under an electron microscope. It emerged that a segment called TMH-2 is vital

"Individual molecules act like Lego bricks, linking together in rings on the surface of a target cell"

for the process that enables each molecule to punch through the membrane (*PLoS Biology*, DOI: 10.1371/journal.pbio.1002049).

This may help us control the "cookie cutting" of pleurotolysin-like proteins. For instance, manipulating the human version, perforin, might help to stop immune cells from attacking our own cells and triggering autoimmune conditions. Whether this will work remains to be seen, as proteins from different species can vary greatly at the molecular level, says Vernon Carruthers at the University of Michigan in Ann Arbor. Colin Barras ■

Mushroom's cookie cutter trick revealed

IT'S a case of Lego molecules doing a cookie cutter's job. The edible oyster mushroom uses a special class of immune system proteins to punch holes in parasites – and possibly prey. Since we and many of our pathogens carry similar proteins, understanding their action could help us fight common diseases.

Most fungi are relatively peaceful,

For forward thinkers



This elastic market is illustrated by the ease for computers in the home. On the one hand are the disbelievers who state that there is only a small range of operations for which the householder will ever need a computer—estimating his taxes once a year, paying bills and balancing budgets once a month and very little else. On the other hand are the optimists who argue that if **microelectronics can make small computers as inexpensive as telephones then people will buy them, even though they are in use for a small fraction of the time. Once in the house, or small office, new uses will be found for them and eventually they will affect life to an even greater extent than the TV set has.**

If the optimists are right then the market is huge. Other markets which are waiting to be opened up are ground and air traffic control, process control of all sorts, medical as well as industrial, and on-line reservation systems. Whether or not microelectronics has this particular future depends on improvements in what we already have today—not on new materials, new phenomena, or new structures. However, if one believes in revolution, then materials other than silicon will be used, and other phenomena and structures besides

New Scientist, 16 March 1972

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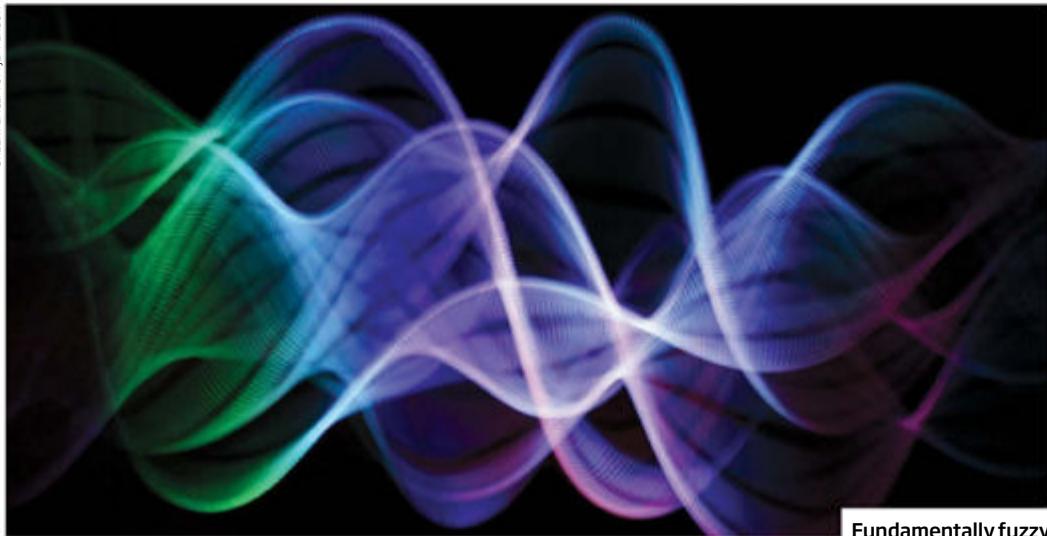
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Fundamentally fuzzy

Quantum wave function gets real

Michael Slezak

IT UNDERPINS the theory of quantum mechanics – but does it actually exist? For nearly a century physicists have argued about whether the wave function is a real part of the world or just a mathematical tool. Now, the first experiment in years to draw a line in the quantum sand suggests we should take it seriously.

The wave function helps predict the results of quantum experiments with incredible accuracy. But it describes a world where particles have fuzzy properties – for example, existing in two places at once. Erwin Schrödinger argued in 1935 that treating the wave function as real leads to the perplexing situation where a cat in a box can be both dead and alive, until someone opens the box and observes it.

Those who want a description of the world that doesn't depend on how you're looking at it have two options: accept that the wave function is real and the cat is both dead and

alive, or argue that the wave function is just a tool that represents our lack of knowledge about the status of the poor cat, sometimes called the "epistemic interpretation".

But very few experiments have been performed that can rule interpretations of quantum mechanics in or out. Now, Alessandro Fedrizzi at the University of Queensland in Australia and his colleagues have measured the reality of the quantum wave function. Their results rule out a large class of

"The wave function is a real part of the world. Schrödinger's cat actually is both dead and alive"

interpretations of quantum mechanics and suggest that if there is any objective description of the world, the wave function is part of it. Schrödinger's cat actually is both dead and alive.

The experiment relies on the quantum properties of something that could be in one of two states, as long as the states are not

complete opposites of each other. Take, for example, a photon that is polarised vertically or on a diagonal, but not horizontally. If the wave function is real, then a single experiment should not be able to determine its polarisation – it can have both until you take more measurements.

If the wave function is not real, then the photon is in a single polarisation state all along, so each measurement can reveal something about the polarisation.

In a complicated setup that involved pairs of photons and hundreds of very accurate readings, the team showed that the wave function must be real: not enough information could be gained about the polarisation of the photons to imply they were in particular states before measurement (*Nature Physics*, doi.org/zvk).

"In my opinion, this is the first experiment to place significant bounds on the viability of an epistemic interpretation of the quantum state," says Matthew Leifer at the Perimeter Institute in Waterloo, Canada.

There are a few ways to save the epistemic view, but they invite other exotic interpretations: killing the wave function could mean leaving open the door to the idea that things that happen in the future can influence the past. ■

Gut bugs could save children from blindness

CHILDREN in many countries are struggling to get the vitamins they need from their nutrient-poor diets. But what if bacteria could allow them to make their own?

Vitamin A deficiency affects about 250 million children worldwide. Around half a million of them go blind every year, and half of those that do die within 12 months. "It's a serious public health issue," says Loredana Quadro at Rutgers University in New Brunswick, New Jersey.

One attempt to tackle the problem is to genetically engineer crops such as Golden Rice, which contain high levels of compounds that the body can convert into vitamin A. But crops are susceptible to weather and can fail, says Quadro, who wants to use microbes to free us from depending on food sources.

Some bacteria produce beta-carotene, the pigment that gives carrots their orange colour. It is also a precursor chemical that our bodies use to make vitamin A. Quadro and her colleagues took the bacterial DNA that codes for this chemical and inserted it into a different strain – one that colonises mouse intestines.

After two weeks living in the guts of lab mice, the bacteria had made themselves at home and were making beta-carotene that could be detected in the gut, bloodstream and liver.

This is the first time engineered bacteria have been used to make beneficial compounds inside a living animal, says Quadro, who presented the findings at the Probiota 2015 conference in Amsterdam, the Netherlands, this week.

But her goal, a one-off probiotic treatment for children at risk of vitamin A deficiency, is still some way off. For a start, such a treatment will have to pass safety tests, and it must persist in the guts of children who may be prone to bouts of diarrhoea, says Alfred Sommer at Johns Hopkins University in Baltimore, Maryland.

Jessica Hamzelou ■

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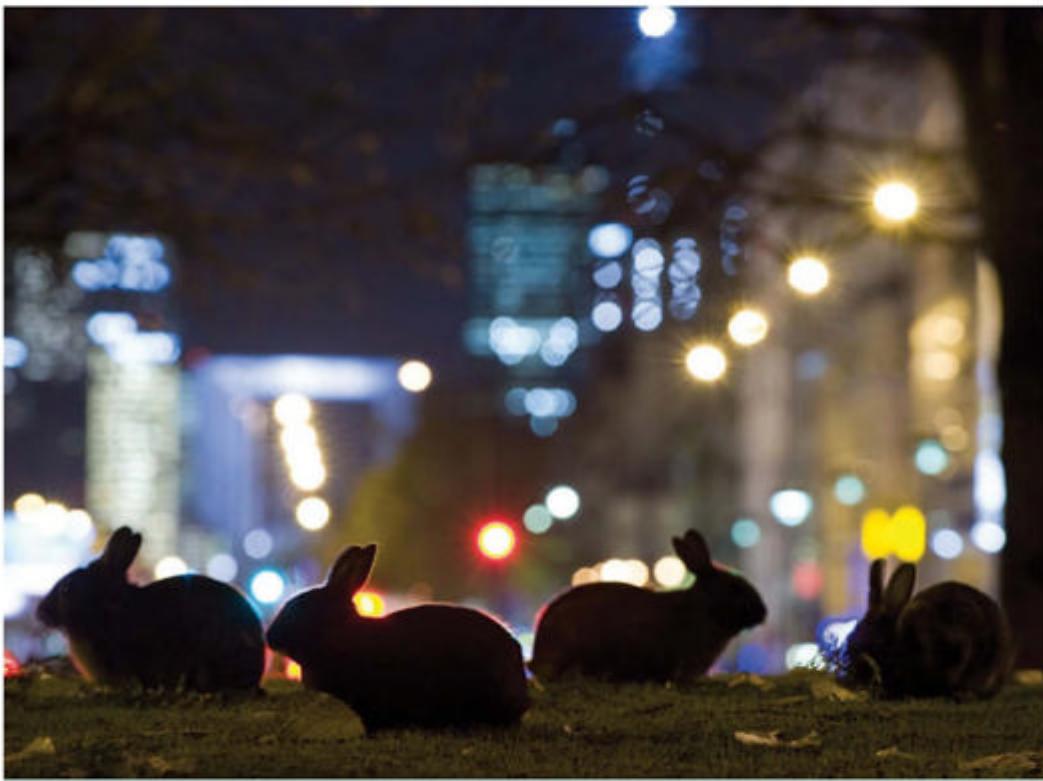
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Big city bunnies thrive in bijou burrows

COTTONTAILS are becoming city slickers. Rural rabbit populations are declining in Europe, whereas city rabbits are thriving. But urban living has caused lifestyle changes: instead of bunching up in complex burrows, city rabbits live a more solitary life in smaller warrens.

Madlen Ziege at the University of Frankfurt, Germany, and her colleagues studied the burrow structures of European rabbits in urban, suburban and rural sites in and around Frankfurt. They found that the closer to the city the burrows were, the smaller, simpler and less populated they became (*Journal of*

Zoology, doi.org/ztw). "I did not expect to find such a clear correlation," says Ziege.

So why are urban rabbits downsizing? Larger groups are a response to scarcity of food and burrowing sites, problems that do not apply in cities. "Cities are providing a constant and high food supply through human waste and deliberate feeding, as well as access to vegetation cover, such as shrubs," says Ziege. And cities tend to be warmer than rural areas, so there is less need for rabbits to huddle together in groups for warmth. The reduced threat from predators in urban landscapes may also abolish the need for complex burrows with many exits.

Ziege says that cities may serve as new habitats for wildlife and be a population source for the recolonisation of rural areas, where rabbits are in decline.

Fifty shades of lilac make it a basic hue

WHEN it comes to colour, one person's peach is another's puce, but there are 11 basic colours that we all agree on. Now it seems two more should be in the mix.

In 1969, two researchers looked at 100 languages and found that all had words for black, white, red, green, yellow, blue, brown, purple, pink, orange and grey. These terms pass a number of tests: they refer to easily distinguishable colours,

are widely used and are single words. There are exceptions – Russian speakers have different words for light and dark blue.

Now Dimitris Mylonas of Queen Mary University of London says the same applies to two more colours. For the past seven years, he has run an online test in which people name a range of shades.

Results from 330 English speakers were analysed to pick out

basic names. These were ranked in a number of ways, such as how often they came up and whether the name was unique to one shade or common to many. Lilac and turquoise came ninth and tenth overall, beating white, red and orange (*Color Research & Application*, doi.org/zsm). Other studies have thrown up additional basic colours, but Mylonas says his large sample gives his findings more weight, at least among English speakers.

Virtual hearts tell of sudden death

SUPERCOMPUTER models of human hearts are helping get to the bottom of sudden arrhythmic death syndrome (SADS).

SADS can result from several genetic conditions that affect the electrical signals making the heart beat. People with such genetic mutations can be treated with drugs or a defibrillator implant, but not everyone with the mutations has the syndrome.

Adam Hill at the Victor Chang Cardiac Research Institute in Sydney, Australia, and his colleagues modelled hundreds of virtual hearts on those of people with different mutations. They found that the risk of dying was linked to the size of the notched T wave – a bump in the ECG readout. They also discovered how the genes that are thought to cause the problem get amplified by complex combinations of other genes (*Nature Communications*, doi.org/zt2).

The mystery of the bird flying out front

IT'S a familiar sight: a flock of birds flying overhead in a V-formation, each saving energy by stealing lift from the bird ahead. But what's in it for the bird out front?

For northern bald ibises, it's all about taking turns. The leading bird often swaps places with the bird behind it. Bernhard Voelkl at the University of Oxford and his team tagged 14 ibises with high-precision GPS data loggers (*PNAS*, DOI: 10.1073/pnas.1413589112).

"For whichever combination of two birds we looked at, we saw that the time bird A was flying in front of bird B matched closely the time bird B was flying in front of bird A," he says. He thinks the results show that the birds are returning favours, in a rare example of reciprocal altruism.

Light twists like a Möbius strip

TWIST a strip of paper, then tape its ends together, and it transforms into a one-sided loop. It's not magic; it's a Möbius strip. These structures show up everywhere from M.C. Escher drawings to electrical circuits, but almost never in nature. But now, physicists have shown that light can form a Möbius shape.

In 2005, Isaac Freund at Bar-Ilan University in Israel suggested that light's polarisation, a property that describes how its electric field moves, could become twisted.

Ten years on, Peter Banzer of the Max Planck Institute in Erlangen, Germany, and his colleagues have shown Freund was right. The team scattered two polarised green laser beams off a gold bead that was smaller than the wavelength of the light. The resulting interference introduced a polarisation pattern with either three or five twists, giving it a Möbius-like structure (*Science*, doi.org/zsn).

"This is the first [experimental] proof that polarisation Möbius strips really exist, which has been a decade-long question in the community," Banzer says. The finding could pave the way for fundamental studies of how light and matter interact, such as using light to trap tiny particles for biomedical purposes.

Freund hailed the study as "a brilliant tour de force".



Lunar lava may have preserved the origins of life on Earth

A DRY, barren rock is not the most obvious place to search for the origins of life. But fossils on the moon may be our best chance of discovering how life began in our solar system.

Experiments suggest that if the precursors to life arrived on Earth encased in a comet or an asteroid, the moon could have preserved a record of it, despite being covered in lava at the time.

The simplest forms of life appeared on Earth 3.8 billion years ago, but no one knows how. Since that crucial time, Earth's tectonic

forces have destroyed almost all the rocks that might have kept records of those times.

If life or its organic precursors were delivered to Earth on asteroids or comets, they should also have hit the moon – which is geologically quiet and so more likely to preserve them. But when life was emerging on Earth, the moon was covered in flows of lava.

To find out whether that lava would have destroyed the organic record, Mark Sephton from Imperial College London and his colleagues put a variety of organic

compounds into artificial moon dust and heated it to 700 °C.

Their results suggest that, far from destroying them, the lava may have sandwiched the organic compounds and preserved them for billions of years (*Astrobiology*, doi.org/zsw).

"Evidence of prebiotic evolution on asteroids and comets or the emergence of life on Earth and Mars could all be preserved," says Sephton. "It is an ironic possibility that one of the best places to look for records of early life is our dry and lifeless moon."

Spider uses judo move to catch prey

WHEN your opponent is heavily armoured, it can help if you are a martial arts expert. The recluse spider of Brazil uses a mix of wit, speed and judo moves to kill and eat one of its toughest prey – the armoured harvestman.

Harvestmen have a hard exoskeleton that usually protects them against predators. Spider fangs slide over the surface of the harvestman's armoured body, making it hard to pin down.

But Rodrigo Willemart at the University of São Paulo, Brazil, and his colleagues found that the recluse spider (*Loxosceles gaucho*) has a way to exploit flaws in the armour's design.

In lab studies, they observed how the recluse spiders approach and feel out the harvestmen with their legs, looking for weak areas. They outrun any escape attempt and then perform a move that Willemart likens to judo, pinning the harvestman's back to the ground. Finally, they deliver a series of venomous bites in the areas not shielded by armour (*Animal Behaviour*, doi.org/zrk).

"They do not try to pierce through the armour. They simply avoid it and bite the soft parts of the harvestman," says Willemart.



KOEN SUYK/AF/GETTY

You've got no chance, we're all larks

FROM diets to shoes, there are lots of ways to maximise sporting performance. For the most keen, there might be another option: time the sport to suit your body clock.

People can be divided into "chronotypes" by what times they naturally rise and sleep. A quarter of us are early risers, or larks, another quarter owls, the rest in the middle.

Roland Brandstaetter of the University of Birmingham in the UK wondered what effect a person's chronotype could have on their sporting performance.

He and a colleague gave 20 hockey

players aerobic fitness tests over several weeks, randomised to six different times of the day. The players' performance changed over the day, in a pattern that depended on their chronotype, as gauged by questionnaires. The owls showed the most variation, performing 26 per cent worse at 7 am than at 7 pm (*Current Biology*, doi.org/zsr).

At an elite level, even a small advantage could make the difference between winning and losing, says Brandstaetter, so some athletes may want to retrain their body clock. "Every body clock can be adjusted."

Red alert for the Sumatran tiger. Fauna & Flora International launches emergency

PHOTO: EUAN BOWEN-JONES/FFI



This Critically Endangered tiger has been pushed to the edge of extinction. You can help save it by donating right now to Fauna & Flora International. Visit www.FFIsumatrantiger.org or cut the coupon below.

One of the Sumatran tiger's final strongholds is under threat from a massive onslaught from poachers. Without action now, this extremely rare big cat faces imminent extinction. Latest surveys show there are perhaps only 500 Sumatran tigers left. We must act now to save them.

- **£83,131 is needed to help us fund more rangers and step up action against the poachers in Kerinci Seblat National Park.**
- **This is one of the final strongholds of the incredibly rare Sumatran tiger, a place where the battle to save the Sumatran tiger will be won or lost.**
- **FFI's work here could be all that stands between the Sumatran tiger and extinction.**
- **The £83,131 needed to fund this urgent work must be raised immediately.**

A 600% increase in snares laid since 2011 has put FFI's anti poaching team on red alert. Habitat loss has already pushed the Sumatran tiger to the brink of extinction but to make matters worse, poachers have stepped up their efforts to snare these magnificent cats.

Fauna & Flora International (FFI) has put out an urgent call to the global community to save the last Sumatran tigers currently existing in the wild – and specifically to employ more rangers. There are now only around 500 Sumatran tigers left.

FFI is urgently seeking funds to step up their crucial conservation programme in Kerinci Seblat National Park, Sumatra, Indonesia. In order to safeguard the future existence of these magnificent creatures, it is imperative that more rangers are employed.

The fact is that, right now, the Sumatran tiger faces a number of very serious threats,

PHOTO: GILL SHAW



"If you value the natural world – if you think it should be protected for its own sake as well as humanity's – then please support Fauna & Flora International."

**Sir David Attenborough,
OM FRS Fauna & Flora
International vice-president**

which are putting their very survival in jeopardy. And, sadly, they are all man-made.

Poaching is a constant danger for the elusive Sumatran tiger – and now poachers have stepped up their efforts. Hunters make good money from the tiger's beautiful skin, which remains in great demand as a status symbol across Indonesia and beyond. Also, its bones are illegally exported to use as ingredients in traditional Asian medicines.

What is really worrying now is that poachers have increased the number of tiger snares

laid by 600% since 2011 and the number of snares found this year have been at almost record levels.

This is against a backdrop of a very serious loss of habitat. In the last 10 to 15 years, natural forest cover in Sumatra has been slashed by almost a staggering 40%. Now a newly emerging threat in 2014, discovered by tiger patrols, is the growth of illegal coffee plantations in Kerinci Seblat National Park.

It is clear why these majestic forest dwellers have been designated as

Critically Endangered on the IUCN Red List, making the Sumatran tiger one of the most endangered tiger subspecies on the planet. This is a rating reserved for animals that face an extremely high risk of extinction in the wild.

Latest surveys have indicated that there may now be as few as 500 existing in the wild. Kerinci Seblat National Park is one of the last places on Earth where they can still be found.

Today, 170 tigers live in and around Kerinci Seblat National Park – the largest known population of tigers anywhere in Sumatra. Since 2007, the number of tigers in the park has stabilised and begun to slowly grow – largely thanks to the vital work of FFI's Tiger Protection and Conservation Programme. However, now the upsurge in poaching puts these gains under threat.

Debbie Martyr, FFI Team Leader of the Kerinci Tiger

appeal in response to 600% increase in poaching threat. 15th February deadline.

Project in Sumatra says:

So far this year our ranger teams walked almost 1,100 miles on forest patrols in and bordering the National Park and destroyed more than 60 active tiger snares - an increase of 600% since 2011. That is why we need to step up patrol regimes.

Tiger populations are dreadfully fragile.

If FFI cannot recruit more rangers to protect the tigers against the increased efforts of the poachers all our good work could be undone.

For all of these reasons, it's now absolutely vital that we keep up our patrols to protect tigers from poachers - and work towards greater protection for their delicate habitat.

If we're going to save the Critically Endangered Sumatran tiger from complete extinction, it's vital that FFI take action now.

But, before that can happen, FFI need to raise £83,131. To do that, the charity is calling on New Scientist readers to make an urgent contribution today.

Please send a gift, by no later than 15th February to help safeguard the future survival of the last few remaining wild Sumatran tigers.

Together, we can save the Sumatran tiger from extinction - but only if we take action immediately.

To take action for the Sumatran tiger please go to www.FFIsumatrantiger.org or cut the coupon.

If the coupon to the bottom right is missing, please send your cheque (payable to FFI) to: FREEPOST RRHG-GBGG-CAGG, Fauna & Flora International, Sumatran Tiger

Appeal, Jupiter House, Station Road, Cambridge, CB1 2JD, UK by 15th February

Fauna & Flora International, founded in 1903, was the world's first international conservation organisation. Today its work spans the globe, with over 140 projects in more than 45 countries. It has a strong history of finding creative solutions to conservation problems and of working with local communities. FFI is supported by the most eminent scientists and members of the conservation movement.



PHOTO: CREDIT: DEBBIE MARTYR/FFI

Poachers kill tiger in Kerinci just two months back: "The team recovered both the skin and bones of the tiger, but more disturbingly we found the remains of the tiger's flesh, which was discarded in the forest near the camp. We knew this particular tiger, a large male, and had recorded it many times on camera traps. To see it reduced from a beautiful wild animal to a pile of meat and guts made us all very angry." Yoan Dinata, Head of the Tiger Monitoring Team, Kerinci Seblat

New Scientist readers: Fauna & Flora International (FFI) has launched an emergency appeal to raise £83,131. This money is needed to help carry out essential conservation work in the Kerinci Seblat National Park in Sumatra.

This work is crucial to the survival of the Critically Endangered Sumatran tiger. Without immediate action, this magnificent big cat could face imminent extinction.

Now New Scientist readers can help fund this essential work - and save the Sumatran tiger from extinction - by cutting the coupon below, calling 01223 431991 or visiting www.FFIsumatrantiger.org. Please respond by 15th February. Thank you for whatever you can do to help.

£83,131 is sought from New Scientist readers to carry out critical conservation work in Kerinci Seblat National Park in Sumatra. These items are on FFI's shopping list of essential needs to help save the 500 Sumatran tigers surviving in the wild.

£5,212 could help us establish two new rangers posts in response to the increase in poaching and pay for essential field equipment. The items needed by our patrol teams in their constant search for poachers are: uniforms, boots, rucksacks, sleeping bags, camping equipment, cooking equipment, field radios and compasses.

£2,500 could buy a second-hand pick-up van to help a patrol travel around Kerinci Seblat National Park and prevent poaching.

£1,714 could buy two motorbikes to help our patrols keep even more mobile in the park.

£857 could pay for laptops for two patrols in order to use GIS mapping devices.

£400 could buy uniforms and boots to be worn whilst on patrol.

£72 could buy essential first aid kits to help deal with medical emergencies whilst out on patrol.

Any donations, large or small, will be received with thanks - and will go a long way towards helping to save the Critically Endangered Sumatran tiger.

I want to help save the remaining 500 Sumatran tigers today, with a donation of £ _____



Title _____ Forename _____ Surname _____

Address _____

Postcode _____

Email _____

Phone No _____

I enclose a cheque payable to Fauna & Flora International **OR**
 I wish to pay by credit/debit card

Type of card: Visa/Amex/Mastercard/Maestro/CAF

Card No:

Start Date: Expiry Date:

Issue Number (Maestro only):

3 digit security code: (Last three digits next to the signature)

Please note: If Fauna & Flora International succeeds in raising more than £83,131 from this appeal, funds will be used wherever they are most needed.

Please return to: Sumatran Tiger Appeal, FREEPOST RRHG-GBGG-CAGG, Fauna & Flora International, Jupiter House, Station Road, Cambridge, CB1 2JD. You can call 01223 431991 to donate now.

Or go to: www.FFIsumatrantiger.org to donate online.

Registered Charity No.1011102. Registered Company No. 2677068.



Cut the coupon below and return it to FFI, together with your gift, to help save the Critically Endangered Sumatran tiger. Alternatively, go to www.FFIsumatrantiger.org. Thank you.

Feel the heat

Using our computers generates plenty of waste heat. Time to harness it to warm our homes, says **Hal Hodson**

EACH photo we “like”, email we send and search we run creates heat. It takes the energy from 34 coal power plants to sustain all digital activities in the US every year, and keeping computing equipment cool accounts for around a third of that energy.

Now a New York start-up called Project Exergy wants to flip that on its head, looking at the heat of computation not as a waste product, but as a valuable resource that can be used to heat our homes.

This isn't the first time waste computing heat has been put to use. Data centres around the world have started to pipe it into offices and apartment blocks where possible, but this only works when there is a large, single building to heat (see “Don't waste the warmth”, below). To bring heat from computing into our homes we need to move the heat source – the servers – into our home too.

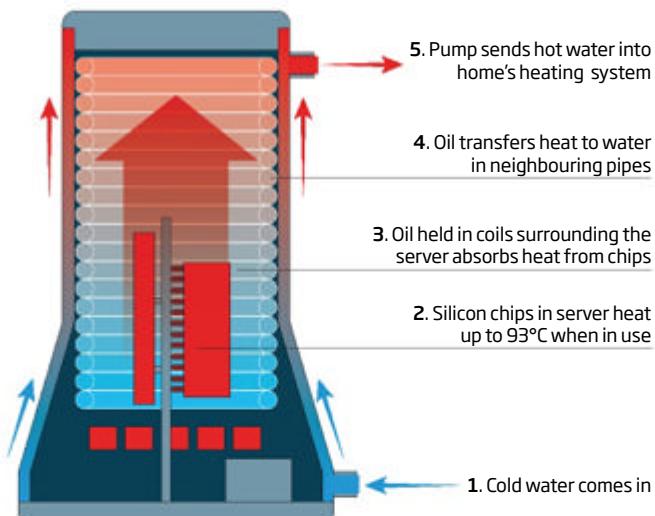
This could make a huge difference. In a 2011 paper called “The Data Furnace”, researchers at Microsoft and the University of Virginia calculated that the IT industry in the US produces enough heat to warm half the country's homes.

Pump it out

That's where Project Exergy comes in. This heating unit contains a computer processor that works as a server crunching numbers for computers and tablets around your home. As you use the processing power, the heat is collected and used to warm the house.

The current prototype, codenamed Henry, uses processors made by the chip

The heat generated by computing could be used to heat your home, if you install Project Exergy's unit



company AMD to run six graphics cards at a temperature of 93 °C. Oil in coils surrounding the chips absorbs waste heat, which is then transferred to water in neighbouring pipes. The water collects in a reservoir that can be hooked up to a home's hot water tank (see diagram, above).

It's possible that the system could be integrated with other sources of waste heat, like ovens and fridges. Founder and CEO Lawrence Orsini says he heated his San Francisco house with the set-up last winter.

“In order to heat your home, you're going to need far more computation than you could personally use,” says Orsini. “So sell it to someone else who needs the computing.” The internet makes this easy, allowing the processors to be accessed from almost anywhere on the planet while the heat from Project Exergy's system remains in the house.

While most of the computation on the device will be sold, some of it will be made available for local needs. “What we're envisioning is a platform where you can displace a game console or even the home security and control systems. You just need the sensors and the unit

SCIENTIFICA/VISUALS UNLIMITED/SPL



DON'T WASTE THE WARMTH

A number of sites around the world are harnessing the heat from computers to keep buildings toasty.

SWIMMING POOL: An IBM data centre keeps the municipal swimming pool balmy in the town of Uitikon, Switzerland. The reclaimed heat has saved 2800 megawatt-hours of energy used to keep the servers of IT company GIB-Services cool.

GRID HEATING: In the bomb shelter beneath the Orthodox Uspenski Cathedral in Helsinki, Finland, 2 megawatts of computation hums

away. Water warmed by cooling these servers is pumped into the city-wide heating system, which serves homes in the city. Enough heat is produced to warm 500 homes.

APARTMENTS: Bitcoin miners have embraced the heating side-effects of the powerful computers they use to crunch random numbers in search of digital wealth. The computation helps to confirm bitcoin transactions and keep the network secure, but many miners report being able to heat their entire apartment with a machine that mints money.



In need of warmth

current chips, boosting the system's heating efficiency.

"I think this is a natural trend for computing in data centres," says David Go of the University of Notre Dame in Indiana. "The people who run data centres, whether large companies like Amazon and Google or smaller data centre companies, are realising that the heat that's generated is useful. Thermodynamically, there's nothing that says this won't work."

"I need a rack-and-a-half of servers to replace my furnace and heat the house. That's nothing"

Project Exergy launched a Kickstarter campaign this week to support more research and development of the prototype, but backers won't be able to actually get their hands on a unit until a later round of crowdfunding. "We haven't priced

the model that would actually go into homes," says Orsini.

The bet that society's need for raw processing power will only grow seems a good one. IBM estimates that 90 per cent of all data created in the history of human civilisation was created in the last two years. Driven by the internet, processing this growth will mean expansion of our computing resources. And half the world is still offline.

There are potential pitfalls in Project Exergy's plan. Home heating systems have evolved little in recent decades – just getting people to buy a new one will be a challenge. And electricity costs could add up for homeowners as processors churn.

Still, Go says that his own calculations show that heating an average home in the US Midwest with computation is very doable. “I need a rack-and-a-half of servers to replace my furnace,” he says. “That’s nothing.” ■

Credit card bills make
you easy to identify

DROP the disguise: your metadata still gives you away. Four hints is all it takes to match almost anyone to their supposedly anonymised credit card records. The findings suggest that tougher measures must be put in place to protect users' privacy.

Yves-Alexandre de Montjoye at the Massachusetts Institute of Technology and his team looked at credit card records over a three-month period from 1.1 million people in an unidentified country. Personal information like names and account numbers had been deleted but the dates and locations of transactions were intact.

They wanted to know whether someone could be identified using a few pieces of extra information - a tweet about dinner with friends, say, or an Instagram snap of a new top from a shopping trip.

For the most part, the answer was yes: for 90 per cent of people, just four pieces of information about where they had gone on what day was enough to pick out which card record was theirs. The four clues didn't have to include anything about what had been bought, although a guess at the approximate price of the transaction did sharpen the team's accuracy. Women and people with higher incomes were easiest to spot, perhaps because these groups had more

diverse behaviour, making individuals distinct from their peers (*Science*, doi.org/zt7).

The results show how hard it is to anonymise large sets of data like credit cards, mobile phones and browsing information, says de Montjoye. "We really need to think

"We really need to think about whether it's even possible to make data truly anonymous"

about what it means to be make data truly anonymous and whether it's even possible."

It also suggests that the lengths that organisations go to to strip data of personal information are of little use. Consumers should seek protection from new tools such as openPDS and the European Union's di.me project, says de Montjoye. These let users control how much of their data third parties can see.

In the meantime, there is little consumers can do to protect themselves without forgoing cellphones and credit cards entirely, says Lorrie Faith Cranor, at Carnegie Mellon University in Pittsburgh. "Short of that, whenever you're asked for data explicitly and you have the opportunity to say no, do it."

Aviva Rutkin



Your privacy? That'll do nicely

Doc-watcher spots when physicians drift

Aviva Rutkin

THE doctor is in – but are they listening to you, or is that iPad on the desk absorbing all their attention?

Electronic records, medical apps, iPads, and other devices and technologies offer numerous potential benefits for healthcare workers and have been widely adopted. But they also create more opportunities for distraction and might erode the quality of care someone receives.

The Lab-in-a-Box aims to change that by analysing doctors as they work. It sits in the corner of their office, keeping tabs on every move, look and word.

Nadir Weibel at the University of California at San Diego, who built the system with a team of colleagues, hopes it will shed light

on what sidetracks doctors during consultations with patients.

“It’s not just what the patient is saying. It’s their facial expression, it’s the way they’re interacting,” says Weibel. “If the doctor is looking at a screen with the patient there, all of that is lost.”

Lab-in-a-Box uses several tools to paint a picture of activity in the office. A Microsoft Kinect depth camera records body and head movements, while an eye-tracker follows the doctor’s gaze and a microphone keeps tabs on who is talking. Meanwhile, software separately installed on the computer captures activity like keyboard strokes, mouse movement and application pop-ups.

The system analyses the various data streams and compares them to moments when the doctor’s

focus is drawn away from the patient. For example, high computer activity paired with rapid eye movement and pupil dilation might indicate that there are too many demands on their attention. Lots of head and eye movement would suggest that the doctor is multitasking between the patient and the computer.

In an ongoing pilot study, Lab-in-a-Box has been set up in doctors’ offices at the UCSD medical centre, the US Veteran’s Affairs Medical Center in San Diego, and several nearby community clinics. Weibel’s team will compare the data across

“Many healthcare professionals don’t realise how attached they are to their devices”

different settings and medical specialities in search of patterns that indicate distraction is likely. The results could help highlight ways to design medical software that is less disruptive.

A future version of Lab-in-a-Box could be permanently placed in a clinic and programmed to provide real-time prompts, warning physicians that they might not be paying enough attention to their patients. “It’s something we’re thinking to do as soon as we have some more understanding about when are the best opportunities to engage physicians,” says Weibel.

Many healthcare professionals don’t realise how attached they are to their devices, says Peter Papadakos, an anaesthesiologist at the University of Rochester in New York. Papadakos has developed a questionnaire to help healthcare workers identify when their technology use has become problematic.

A tool like Lab-in-a-Box could be the wake-up call that screen-addicted docs need, he says. “I think this is going to be a fascinating device. It will be yet another way to show people that they need to focus.” ■



Better without a screen in the way



Virtual Sundance

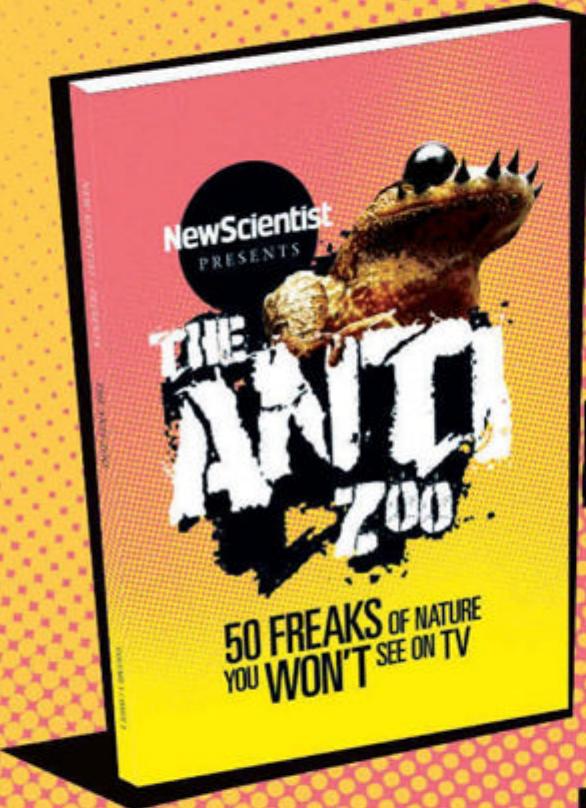
Virtual reality is hitting the film festival scene. At the Sundance Film Festival in Park City, Utah, last week, several short films debuted that are made to be watched in VR using headsets like the Oculus Rift. In *Wild – The Experience*, festival goers join Reese Witherspoon as she hikes the Pacific Crest Trail. *Project Syria* puts the watcher at the centre of a rocket attack.

“Going to the big game? Have fun, cheer on your team and keep it a no drone zone”

Before last weekend’s Super Bowl the US government released a video warning that drones were banned from flying within 50 kilometres of the stadium in Glendale, Arizona

Robot hotel to open

When the Henn na Hotel opens in Japan this July it will have some rather unusual staff members. Robots will work as porters, cleaners and receptionists. Whether they will be assigned other tasks is unknown, but some aspects of the hospitality industry could prove challenging. Folding a towel, for example, currently takes a robot 6 minutes. That would leave guests waiting a long time for fresh linen.



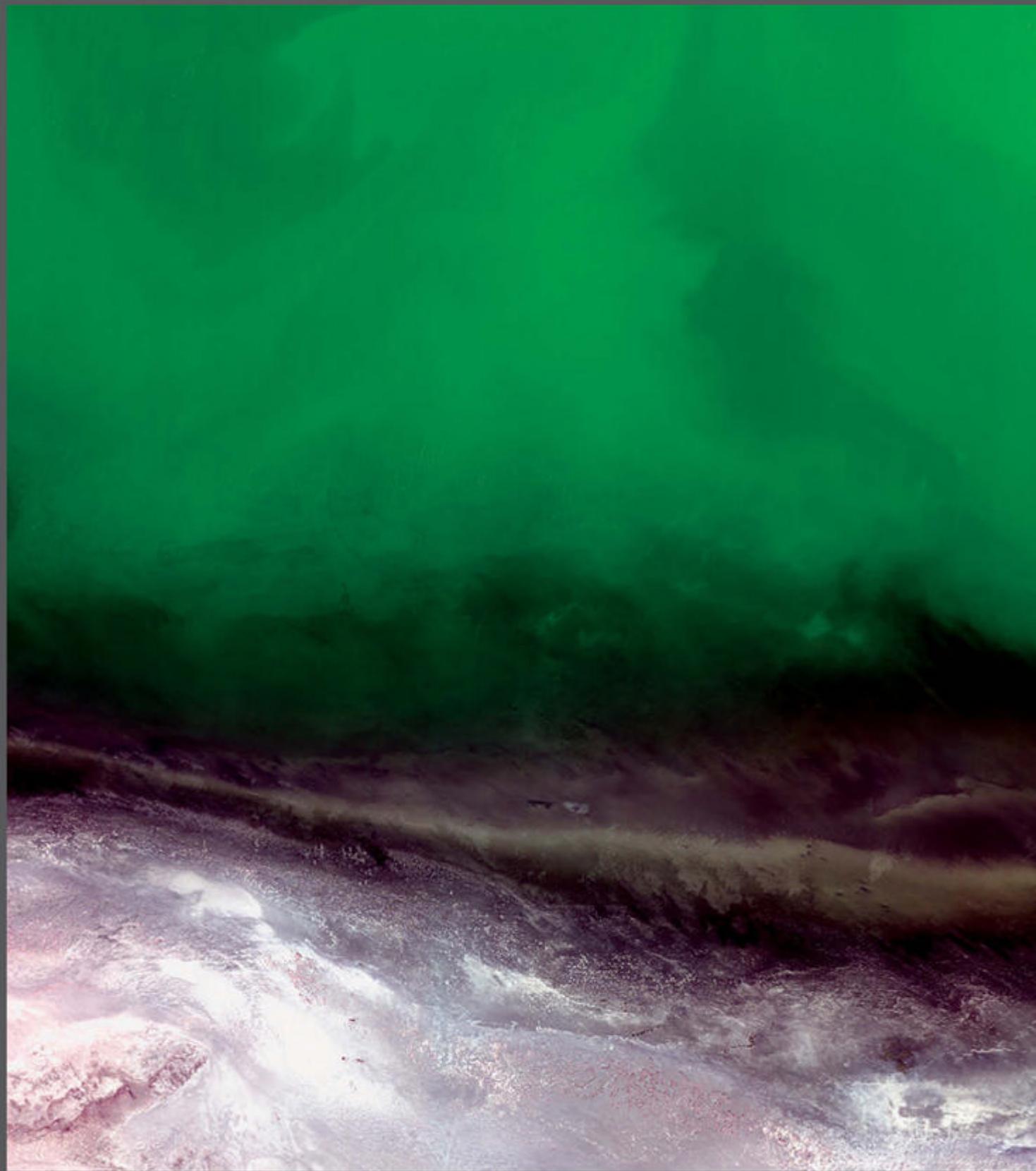
Take a walk on the wild side

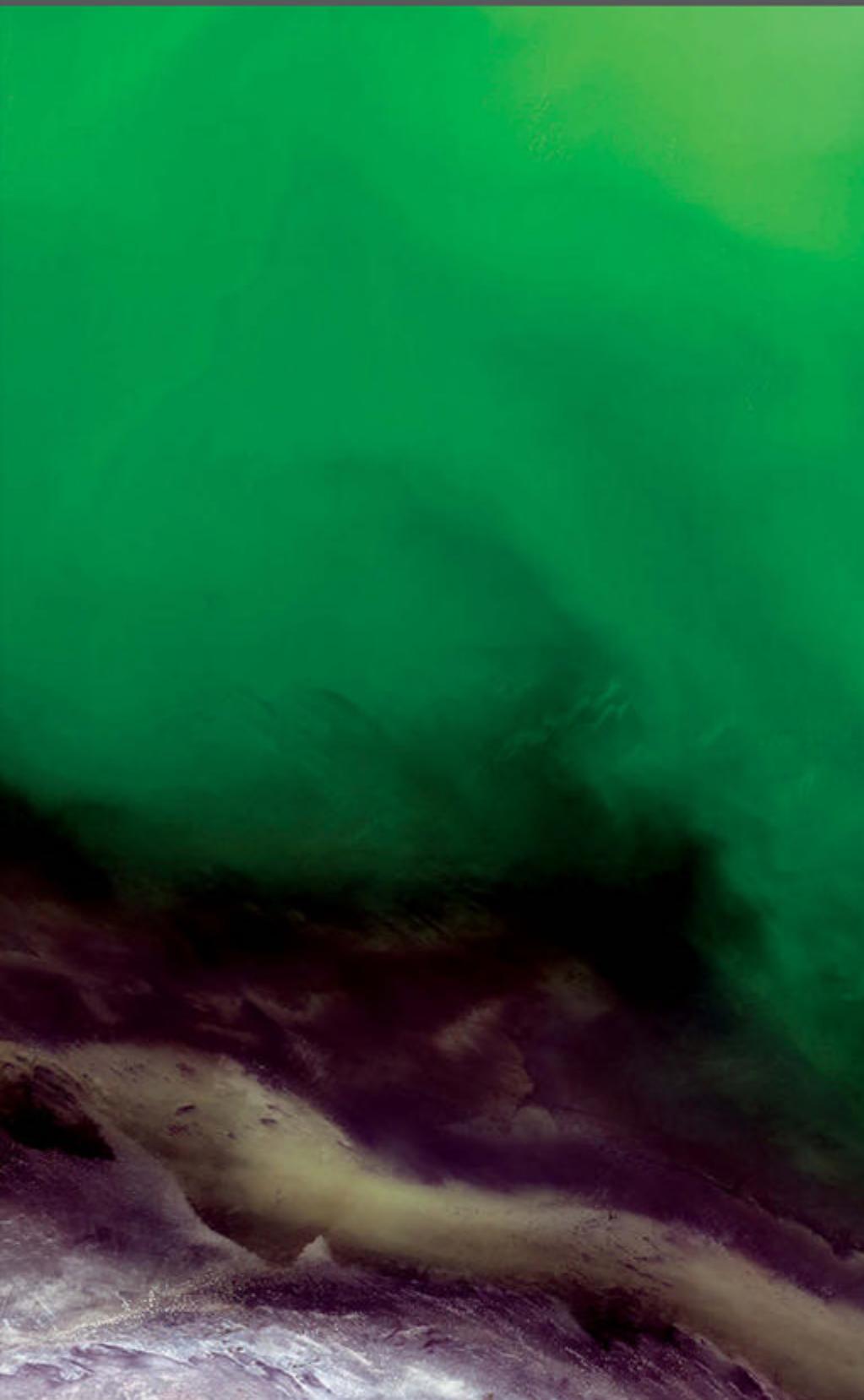
Which animal has the biggest mouth?
Can alligators use tools?
Could a mouse beat a scorpion in a fight?

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NewScientist





A massive pea-souper

YOU'RE looking at a gigantic algal bloom - seen from space. This is the Caspian Sea, located between Europe and Asia, bordered by Russia, Azerbaijan, Iran, Turkmenistan and, seen in the lower portion of the photograph, Kazakhstan.

The sea - or lake, if you prefer, as it is landlocked - is enormous, with a surface area of 371,000 square kilometres. It's larger than Germany. But the section seen here is shallow, only around 5 metres deep. It is also polluted by phosphorus from fertiliser, raw sewage and detergents, and the super-enriched water triggers massive growth of algae just as it inhibits and reduces other aquatic life. The image was taken by South Korea's Komsat-2 satellite. Rowan Hooper



Photograph
KARI/ESA

Holding violence down

Violent crime is falling dramatically in many nations. How can we ensure this trend continues, wonders **Manuel Eisner**

VIOLENT crime is on the retreat in most advanced economies. The latest US figures, for 2013, show that murder rates are lower now than in the early 1960s. In the same year, homicides in Japan hit a post-war low. In England and Wales the level of violence has dropped by 66 per cent since the latest peak in 1995.

In fact, big falls in homicides have happened in virtually all developed societies over the past 20 years. In the US, it is clear that the decline in violence extends to robbery, assault, rape, child maltreatment, domestic abuse and school bullying.

Why crime rose sharply in the second half of the 20th century before falling dramatically is open to debate. The causes are complex, and we are only starting to unravel them. It is also clear that in some nations homicide rates remain stubbornly high.

Against this backdrop, leading scholars believe that non-conflict violence could be halved across the world in the next 30 years.

So what have we learned from the recent crime fall in developed nations that could help? Some explanations are controversial – for example, linking it to the harmful impact of lead exposure, shown to heighten aggression and dysfunctional behaviour, and the banning of lead in petrol – but others are more broadly accepted.

A drop in societal violence often appears to be linked to social control technologies, including monitoring technologies, as well as increased control over disorderly conduct, and systems aimed at early identification of



offenders. Some of the decline in crime across the Western world is probably a side effect of building more effective security and surveillance technologies into everyday life. These include central deadlocking systems in vehicles, better and more widespread home protection technologies, more CCTV cameras, and the move away from a cash-based economy. This raises important issues for reducing violence in developing nations, as it implies that violence prevention needs to be built in from the start, for example, in communication technologies and urban infrastructure.

In addition, any attempt to shift

high violence rates must note that homicide declines are often triggered by influential groups or individuals emphasising the importance of self-control, civility and respect, changing societal views on harming others. Over the last 20 years much evidence suggests that in the West we have become less tolerant of violence, maybe as part of an ongoing civilising process that stretches back centuries. Bullying is no longer seen as a normal part of going to school, nor is it

'Half the world's 450,000 homicides are in just 20 nations in Latin America and sub-Saharan Africa'

acceptable for parents to lash out at children, and tolerance of racially and sexually abusive language has shrunk. The public outcry about recent sexual abuse scandals in the UK involving high-profile individuals is not a sign that things are getting worse. Most of the offences date back decades anyway. What it does show is that we have become more intolerant of abusive behaviour by powerful people.

Improving policing in nations with stubbornly high violent crime is also important. This is another likely factor driving the current decline in violence in the West, where evidence-based policing methods started to take hold in the final decade of the 20th century. On this front, Lawrence Sherman, director of the Institute of Criminology at the University of Cambridge, recommends using the "triple-T" strategy: targeting scarce resources by focusing on predictable concentrations of crime and disorder; testing police practices to help choose those that work best to reduce harm; and tracking the delivery and effects of those practices.

Longer-term trends are also informative, especially in homicide – which has gone down in recent centuries in wealthier countries, despite intermittent upsurges. Historically, homicide rates have declined where states established an effective rule of law, curbing the corruption of officials, gaining control over private protection markets, and where states became more legitimate through accountable

institutions, winning greater public trust. Any strategy to reduce violent crime in less-developed parts of the world must therefore also target political elites, who must commit to the rule of law, improved governance and inclusive state services.

Tackling violence in countries where it remains stubbornly high is important for economic as well as humanitarian reasons. The Copenhagen Consensus Center, which promotes an evidence-based approach to improving welfare worldwide, puts the global costs of violence, excluding conflicts, at \$9.5 trillion a year, equivalent to around 11 per cent of world GDP. Homicides, violent crime, child abuse, domestic violence and sexual violence account for most of the cost.

While studies of downward crime trends offer guidance, if we are to turn global violence reduction into a coherent field of action, we need a lot more knowledge. We need monitoring systems that describe different kinds of violence at global, national and regional levels so we can direct action to where it is needed most. Additionally, we will need to overcome the massive gap between where the knowledge is and where the needs are greatest.

Half of all the world's 450,000 homicides each year occur in just 20 countries. All are in Latin America or sub-Saharan Africa, account for a mere 10 per cent of the world population, and have very limited research capacity. In contrast, 95 per cent of all knowledge on effective violence prevention relates to the US and wealthy European countries.

While work continues to fully understand the crime declines in these countries, it is now essential to build research capacity in low and middle income countries too, so they can follow suit and enjoy a safer future. ■

Manuel Eisner heads the Violence Research Centre at the University of Cambridge Institute of Criminology

ONE MINUTE INTERVIEW

Death in the digital age

Put your online affairs in order and donate your body to open-source science when you die. **Willow Brugh** explains how



PROFILE

Willow Brugh is a research affiliate at MIT's Center for Civic Media and the community leadership strategist at Aspiration in San Francisco, a firm that provides technological tools and training for social justice non-profit organisations

What got you thinking about our digital legacy after we die?

Some of my friends, and friends of friends, dying in quick succession. That already sucks, but then you also have to deal with their online artefacts and the invasion of their privacy to get into their computer to retrieve their memories or make sure the things they're working on get published. I thought about how to digitally deal with my own death and how to ease that transition for the people I care about.

What are the necessary considerations?

To balance your own desires with the wishes of those you care about and with the wider society. And where do the wishes of those you care about matter more – the stories they don't want told, for example.

What steps can people take?

Consider what you want your trusted people to have access to, such as your passwords and materials, and how they will gain access – a cloud-

based password vault, for example. And you need a mechanism that notifies them – something like an email triggered by a dead man's switch that automatically kicks in when you die because you're not there to cancel it. Then you do an online "death drill". It's a terrible name, but a great way to make sure that what you've put in place works.

What do you mean by a death drill?

It's a chance to test the infrastructure you've created. Will your mailing list deploy correctly? Can the recipients access your password vault? You troubleshoot with friends, with their clear understanding that these drills will happen.

You're also exploring the way in which people can donate their bodies to science. Why?

I wondered how it would look to apply an open-source framework to human anatomy and bodies in general. The idea is that the people who sign up for open-source donation will have something interesting about their physiology, and that the data generated from their bodies will be freely available. The question is how to make the donation robust, so it won't be a hassle for family and friends.

Why would open-source donation be useful?

More eyes on any challenge leads to more options for overcoming that challenge. A great example is 18-year-old Jack Andraka, who designed a test for pancreatic cancer after turning to Wikipedia, Google and free online journals. When advances are made in back rooms, only those who can afford access gain benefits, and that's bullshit.

How can people donate their bodies this way?

One scenario is where someone donates their tissue samples to a family member, who then donates those tissues to an open-science repository. Piecemeal but easier. The other main one is to work with a scientific institutional review board in combination with a research hospital, to try to do something with whole bodies. This is the one that we still need to work out.

Interview by Aviva Rutkin

Trauma ripples through generations

Israel, once dubbed “the stress laboratory of the world”, is a country of constant strife – sadly, a perfect place for **Zahava Solomon** to explore the after-effects of armed conflict

What made you choose a career in trauma research?

My mother was in Auschwitz. That has shaped my career, my choice of field. I was very close to my mother. She was one of the very few survivors who talked about her experiences.

How do you characterise a traumatic event?

Any event that puts someone in danger of death or serious injury. Most people exposed to traumatic events cope in an effective way, even though they may feel upset by it. A traumatic response, on the other hand, entails a collapse of the coping mechanism, when someone is flooded by anxiety. The most conspicuous outcome of this is post-traumatic stress disorder. People with PTSD experience continuous trauma. Despite the fact that the traumatic event is over – the war has finished and they have been reunited with their family – they still feel they are experiencing it. This can take the form of flashbacks: they might hear the screams of their comrades, or smell the blood or the gunpowder.

How do people respond to trauma?

By trying to distance themselves from it, which results in psychic numbing and avoidance – trying to numb their psyche so they will not be tormented and haunted by the pain. There is an inner struggle between re-experiencing the event and breaking away from it. Avoidance translates into specific behaviours: somebody may choose not to eat watermelon because it's red and red reminds them of blood.

Another symptom is hyperarousal: after a traumatic event, they know the world is a very dangerous place, and they feel hypervigilant all the time as a result.

You've found that people who have experienced trauma are more likely to contract diseases and die early. Why does that happen?

There are a number of pathways. For instance, if you are always hypervigilant, you expend a lot of energy just for survival. Lack of sleep, especially over long periods of time, is associated with increased mortality. These people age before their time. They also have a sense of a foreshortened future. They are more likely to abuse alcohol or drugs, which in the short-term might alleviate their distress, but in the long-term will be detrimental to their recovery. They are usually quite stressed. They don't exercise, they don't take care of themselves, they don't eat properly.

“Everybody's ability to withstand traumatic events eventually breaks down”

Do certain battlefield experiences cause particularly traumatic reactions?

Seeing a friend killed is the worst, or seeing your commander killed, because he was like a father to you and you depended on him for your survival. Or seeing other horrendous things. Also, if you changed places on the front line with someone else and they got killed. There is a lot of survivor guilt.

Why are some people more affected by traumatic events than others?

Finding this out is the main challenge in our field. We do know that under extreme stress individual variability almost disappears: eventually everybody's ability to withstand traumatic events breaks down. If you put enough pressure on a human being, they will succumb. During the first world war,

the number of cases of shell shock was staggering, because the war was such a prolonged and terrible experience.

There are risk factors. For instance, prisoners of war who are more educated seem to cope better with their captivity.

Does culture influence responses to trauma?

The way people express distress is certainly coloured by their culture. For instance, the Spanish recorded much higher rates of PTSD after the terrorist attacks in Madrid in 2004 than the British did after the suicide bombings in London in 2005. Some of my British colleagues say PTSD never crossed the Atlantic and is an American invention. The British are more reserved and less inclined to disclose or be distressed by traumatic events. At the same time, in the British army there are a lot more cases of alcoholism than in Israel, where it is relatively low. Alcoholism often masks PTSD.

Have you studied Palestinian populations?

It is very difficult to do that in the Palestinian territories as there are practical obstacles such as military checkpoints, and also moral issues. However, as soon as I finished my Israeli army service, one of my first studies was with Palestinian colleagues on children in the West Bank. We found that an extremely high proportion of these youngsters had PTSD, and especially a sense of foreshortened future. In many cases, they don't see themselves growing old, getting married, having families or starting a career. That could have dire consequences for the future of the region.

What about Palestinian citizens of Israel?

We studied them during the second Palestinian intifada – between 2000 and 2005. They

Photographed for New Scientist by Jonathan Bloom



PROFILE

Psychologist Zahava Solomon of Tel Aviv University, Israel, explores the traumatic effects of combat and war captivity

The Wall of Names at the armored corps memorial site in Latrun, Israel

seemed to have higher rates of PTSD than their Jewish Israeli counterparts. Clearly they were not exposed to more traumatic stress: there were a lot more Jewish casualties during that period. It had to do with social marginality. For them, the conflict was immense, because it was “my people fighting my country”, which was an impossible situation.

You and others have found that parents who have experienced trauma can pass the effects on to their children. How?

This has been documented in many studies of Holocaust survivors and other traumatised populations. Recent studies in epigenetics suggest that trauma triggers some kind of alteration in people's epigenetic make-up, to do with the way stress and emotion are regulated, which is then passed on to their children, although this is still controversial.

A more obvious cause has to do with parenting – when the parents are present yet not present at the same time. It is very difficult for a child to grow up with a traumatised father, to have a father who is like the tin man in *The Wizard of Oz*, who can't feel anything.

How does this second-generation trauma express itself in the children?

Often it only becomes apparent when they are exposed to a traumatic situation themselves. In a pioneering study we looked at combat stress reactions during the first Lebanon war in 1982, and looked back at the people's family history to see if they were children of Holocaust survivors. We found that children of people who were traumatised during the Holocaust, despite appearing to be socially and psychologically well-functioning before the war, were less well equipped to deal with their own traumatic battlefield experiences. They were debilitated for longer.

In what way might that be due to the effects of parenting?

These individuals have a lot of qualms about aggression. It's very difficult for someone who comes from that kind of background to be an aggressor, there's an underlying vulnerability.

How has being the daughter of a Holocaust survivor affected you?

My mother was very open with me about her experiences, but that never traumatised me. For her, my birth was sort of a ray of hope and a victory. She told me stories about how she and her siblings helped each other. I heard a lot of brave things about how they were going to sacrifice their lives for each other. So as far as I can tell, it affected me in a positive way. Although I do have a lot of qualms about aggression. And I'm also quite anxious. ■

Interview by Michael Bond



Automated systems are running the show – often in secret. Hal Hodson lifts the curtain

NO ONE IN CONTROL

AMAZON is all kinds of broken." If you caught that tweet on 12 December last year, and were quick, you might have grabbed some exceptional bargains. For an hour only, Amazon was selling an odd mix of items – cellphones, video games, fancy-dress costumes, mattresses – for one penny.

The surprise price drop cost sellers dearly. Goods usually marked £100 went for a 99.99 per cent discount. Hundreds of customers leapt at the chance, often buying in bulk. Even though Amazon reacted quickly and cancelled many orders, they were unable to recall those that their automated system had already dispatched from warehouses. Once set in motion, the process was hard to stop. Thanks to a software glitch, a handful of independent traders using Amazon's Marketplace lost stock worth tens of thousands of dollars. Some faced bankruptcy.

We only notice when algorithms go wrong. Most of the time they get on with business out of sight and out of mind. And business is booming. Automated processes are no longer simply tools at our disposal: they often make the decisions themselves. Much of the news we read, the music we listen to and the products we buy are served up automatically, based on statistical guesswork about what we want. Invisible chaperones shape our online experiences. Systems we can't examine and don't understand determine the route we take to work, the rates we get for mortgages, and the price we see for airfares.

Many are proprietary and all are complex, pushing them beyond public scrutiny. How can we be sure they're playing fair? A new wave of algorithm auditors are on the case, intent on pulling back the curtain on the hidden workings and hunting for undue bias or discrimination. But is this the fix?

Do algorithms need better policing, or must we accept their nature as a price we pay for our automated world?

There's nothing inherently mysterious about them: an algorithm is simply a set of instructions for getting something done. The trouble is that algorithms get nested inside or bolted on to others, interacting in ever more complex ways. It can also be hard to predict how algorithms will behave with real-world data once released into the wild.

The scope of their influence is often unclear. Some people swear blind that they've seen the price of flights on one website jump after checking out a rival site, for example. Others think that's bunk, an urban myth for our times. Such debates highlight the shadowy nature of today's systems.

Not only are most algorithms secret recipes, sometimes even the developers who wrote them are in the dark. When Aniko Hannak at Northeastern University in Boston, Massachusetts, looked closely at how many of us have our search results skewed by

factors like location and browsing history, she noted things even Google didn't know: for example, that around 12 per cent of searches get personalised. Google engineers thanked her. They'd never made such measurements and hadn't known the exact impact of their personalisation algorithms.

Exposing hidden algorithms can cause outrage. That's what Christian Sandvig and his colleagues at the University of Michigan, Ann Arbor, found when they lifted the lid on Facebook's newsfeed algorithms, which decide which posts from friends and family we actually see. The team compared filtered and unfiltered feeds and found that Facebook's algorithms hid posts deemed uninteresting, according to unspecified criteria.

Around two-thirds of the participants in Sandvig's study had no idea that algorithms were deciding what they saw. Many were shocked and upset when posts from close friends or family were excluded. Some had been blaming themselves or their friends for the algorithms' work. "If you post something and it doesn't get any comments or likes, people assume that either their friends don't like the topic, or their friends don't like them," says Sandvig.

Even for news, it's a popularity contest. During last year's Ferguson riots in Missouri, for example, Facebook's newsfeeds were filled with posts about the Ice Bucket Challenge because these had hundreds of thousands of likes.

What Sandvig's team did for Facebook, Hannak and her colleagues are doing for other online activity. Hannak is interested in how algorithms can tailor prices to different shoppers. In one recent study, the researchers looked at how online retailers such as Walmart, Office Depot and Expedia varied

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prices according to factors including a user's choice of browser, operating system and purchase history.

They found many instances of what they consider price discrimination though they are not sure of the rationale. Often the difference was small. Android users, for example, saw higher prices on about 6 per cent of items, though only by a few cents. In other cases, price quotes varied by up to \$100. The greatest differences were typically seen between users who were logged in to a site and those who were not.

CRASH DAMAGE

Hannak's group now wants to understand exactly how location influences search results. They are simulating hundreds of Android phones and spreading them across Ohio using faked GPS coordinates. They'll also be looking to see whether people from rich and poor neighbourhoods get different search results when hunting for financial services.

Evidence of that may already have come to light. Some think hidden algorithms played a part in the 2008 sub-prime mortgage crash. Between 2000 and 2007, US lenders like Countrywide Home Loans and DeepGreen doled out home loans at an unprecedented rate via automated online applications.

"Everyone was saying what a great innovation it was," says Dan Power at the University of Northern Iowa in Cedar Falls. "Everyone was very high on these fast web-based loans. No one anticipated the problem."

The problem was granting so many high-risk loans without human oversight. Americans from minority groups suffered

most in the resulting crash. Automated processes crunched through vast amounts of data to identify high-risk borrowers – who are charged higher interest rates – and targeted them to sell mortgages. "Those borrowers turned out to be disproportionately African American and Latino," says Seeta Gangadharan of the Open Technology Institute, a public policy think tank based in Washington DC. "Algorithms played a role in that process."

The exact degree to which algorithms were to blame remains unclear. But banks like Wells Fargo and Bank of America settled with several cities, including Baltimore, Chicago, Los Angeles and Philadelphia, for hundreds of millions of dollars over claims that their sub-prime lending had disproportionately affected minorities. Although the decision-making process big banks used to target and sell sub-prime loans may not have been new in itself, the reach and speed of those decisions when algorithms were the driving force was new. "It's the scale factor," says Gangadharan. "This was a problem that affected many people in the US and we have seen the effects fall along race and class lines in devastating ways."

Automated systems are replacing human discretion in ever more important decisions. In 2012, the US State Department started using an algorithm to randomly select the winners of the green card lottery. The system was buggy, however: it awarded visas only to people who applied on the first day, says Josh Kroll, a Princeton University computer scientist who is investigating the event. Those visas were rescinded, but it's a good example of how hidden algorithms can have a life-changing effect.

In a similar example, the documents leaked by Edward Snowden revealed that the National Security Agency uses algorithms to decide

whether a person is a US citizen. According to US law, only non-citizens can have their communications monitored without a warrant. In the absence of information about an individual's birthplace or parents' citizenship, the NSA algorithms use other criteria. Is this person in contact with foreigners? Do they appear to have accessed the internet from a foreign country? Depending on what you do online, your citizenship might change overnight. "One day you might be a citizen, another you might be a foreigner," says John Cheney-Lippold, at the University of Michigan in Ann Arbor. "It's a categorical assessment based on an interpretation of your data, not your passport or your birth certificate."

Algorithms are also used to police voter fraud. Several US states use software called Crosscheck to remove duplicate entries from electoral registers. But people have been deleted simply for having the same name. As with the sub-prime algorithms, minorities are again hit hardest. The names it scrubs are disproportionately those of black, Asian and Hispanic voters, who are more likely to share names – such as Jackson, Kim or Garcia.

The next scandal may be prison sentencing. Judges and lawyers in Missouri can use a website to make an "Automated Sentencing Application". The system calculates incarceration costs for defendants, and weighs that against the likelihood the defendant will reoffend, based on prior criminal history and behavioural and demographic factors. Some think this will lead to minorities being given harsher sentences. Proxies like address, income and education level make it almost impossible to avoid racial bias. Similar systems are appearing across the US. "I think it's terrifying," says Sorelle Friedler, a computer scientist at Haverford College in Pennsylvania.

Are systems that pick what you see keeping you in the dark?



Automated decisions may have culminated in sub-prime misery



ANDREW LICHENSTEIN / POLARIS / EYEVINE

The scales are falling from our eyes as the impact of algorithms is felt in almost every area of our lives. What should we do about it? In many of these examples, the problem is not the algorithms themselves, but the fact that they over-amplify an existing bias in the data.

HIGHER STANDARDS

"People who work with algorithms are comfortable with the idea that they might produce these unintended results," says Sandvig. But for a growing number of people, that's not good enough. Christo Wilson, who works with Hannak at Northeastern University, thinks that large technology companies like Google and Facebook ought to be considered as public services that huge numbers of people rely on. "Given that they have a billion eyeballs, I think they have a responsibility to hold themselves to a higher standard," he says.

Wilson thinks that automated systems might be made more trustworthy if users can control exactly how their results are personalised – such as leaving gender out of the equation or ignoring income bracket and address. It would also help us learn how these systems work, he says.

Others are calling for a new regulatory framework governing algorithms, much like we have for the financial industry, for example. A recent report commissioned by the White House recommends that policy-makers pay more attention to what the algorithms do with the data they collect and analyse. To ensure accountability, however, there would need to be independent auditors who inspect algorithms and monitor their

impact. We cannot leave it to governments or industry alone to respond to the problems, says Gangadharan.

"The big question now for me is who are the watchdogs," says Sandvig. For now, he suggests it should be the researchers who are beginning to reveal algorithms' broader effects. Wilson, for example, is looking into setting up dummy credit profiles to better understand price-fixing systems. But independent auditors face tough obstacles. For a start, digging around inside many automated services violates their terms of use agreement, which prohibits attempts to analyse how they work. Under the US Computer Fraud and Abuse Act, such snooping may even be illegal. And while public scrutiny is important, the details of proprietary algorithms need to be kept safe from competitors or hackers, for example.

What's more, most automated systems are too complex for humans to inspect by hand.

So some researchers have developed algorithms that check other algorithms. Kroll is working on a system that would let an auditor verify that an algorithm did what it was supposed to with what it was given. In other words, it would provide a foolproof way of checking that the outcome of the green card lottery, for example, was in fact random. Or that a driverless car's algorithm for avoiding pedestrians treats both people walking and people in wheelchairs with the same caution.

Friedler has a different approach. By understanding the biases inherent in the underlying data, she hopes to eliminate bias in the algorithm. Her system looks for correlations between arbitrary properties – like height or address – and demographic groupings like race or gender. If the correlation is expected to lead to unwanted bias, then it would make sense to normalise the data. It is essentially affirmative action for algorithms, she says.

That's fine for cases where discrimination is clear, where a system is found to be unfair or illegal. But what if there is disagreement about how an algorithm ought to behave? Many would say Facebook's filtering of its newsfeed keeps it readable. Some would argue that highly personalised price adjustment can benefit both customers and retailers. What's acceptable to some won't be for others.

As Sandvig notes, unlike for financial systems, there are no standards of practice governing algorithms. But how we want them to behave may turn out to be a harder question for society to answer than we think. Maybe we'll need an algorithm for that. ■

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"HOW WE WANT
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Hal Hodson is a reporter at *New Scientist*

SPECIAL REPORT

The secret life of your home



There's no place like it. It's where the heart is. It's a castle. Where we live is special to us. And no wonder when you consider how much time we spend there.

But did you know that your house has its own ecosystem and climate? That it can even manipulate your mood and behaviour? Andy Ridgway invites you in ...

Walls can talk

Beige walls. A parking ticket discarded on the kitchen counter. Files neatly placed on the desk in the corner of the living room. Even the banal, mundane and seemingly insignificant aspects of our homes reveal a surprising amount about us. They lay our personalities bare.

Psychologist Sam Gosling at the University of Texas at Austin can tell a lot about a person from their belongings and the way they are arranged. His landmark study in 2008 centred on the dorms of college students, which start each term bare and identical and within weeks reflect the personalities of their occupants.

Lately, Gosling and his team have turned their attention to a more complicated problem, the living rooms of couples. "People often have no insight into how their spaces relate to their psychology," says Gosling. "That's why when couples move in together it can cause so much consternation because what seems a perfectly natural thing to do in one's space is contested by your partner."

Some things we deliberately put on show to say something about ourselves. "It could be a photo of our wedding day, a poster of our favourite band or a flag from our home country," says Lindsay Graham who worked on the study with Gosling. These are known as identity claims.

Then there are the items and decor that actively influence our thoughts and feelings. We're not deliberately saying something about ourselves with these, but they still speak volumes. "If we're trying to create intimacy or cosiness, we may arrange furniture so it encircles the centre of the room," says Graham. The very fact you have arranged it this way reveals that socialising is important to you.

The lighting, keepsakes we place on shelves, the colours we paint our walls – these all control emotion too. "Colours in particular are things that regulate how we want to feel or an impression we want to convey," says Graham. "Beige walls, for instance, could reflect not being open because you are conventionally going with the trend, or it could be a reflection of knowing what's current and modern."

But the items that perhaps reveal the most about us are the "behavioural residue" – the things that materialise as we live our lives. "It might be a parking ticket," says Graham. "It gives some indication of how people behave outside the home. Perhaps they weren't being conscientious and minding the signs,

A LIVING ROOM NEVER LIES

Three personality traits that can be read from your home

OPENNESS TO IDEAS:

Rooms filled with distinctive or unusual objects. Original art rather than popular posters. Books on varied topics.

CONSCIENTIOUSNESS:

Neat, tidy, organised spaces.

EXTROVERSION:

Chairs organised in a way that allows people to socialise. Lots of glasses for entertaining people. A home set up to allow large-scale interaction.

or maybe they were being impulsive. In some ways, the behavioural residue is the most interesting because it's not being monitored."

Gosling and Graham want to know whether you can still glean anything about the individuals who share a home – and whether it can reveal secrets about the couple's relationship.

Working with four students, Graham visited the living rooms of 100 couples. They made meticulous records of everything, taking between 8000 and 10,000 photos. Graham is now combing through these observations and attempting to marry them with personality surveys filled out by each couple.

It's still early days for the research. "One thing is clear," says Graham. "There are traces of behaviours present, such as an alphabetised record collection, piles of unopened bills and open laptops on coffee tables that are clues about the daily lives these couples share."

My house made me do it

Our personalities shape our homes, but it's not one-way traffic: they exert a powerful psychological effect on us too. Take the way it smells. "If there are clean smells in the house, you are more likely to keep it clean," says Paul Dolan, a psychologist at the London School of Economics.

In one study carried out in 2005, Dutch psychologists found that the aroma from a hidden bucket of citrus-smelling cleaner was enough to make volunteers do a much better job of cleaning up biscuit crumbs – even though they weren't aware of the scent. Although the research was carried

"If there are clean smells in your home, you're more likely to keep it clean"

out in a lab, Dolan suspects that we are likely to behave in a similar way at home.

Architect Chris Travis takes this even further. He believes that the most powerful influences our homes have on us come from our past, through associations we make subconsciously. At his design company, Truehome Design Build in Round Top, Texas, he takes an unusual approach with his clients. Instead of asking what materials they like and where they would like the windows to go, he asks about a time when they felt safe, comfortable, provided for and so on. Travis then shapes the design of the client's house to evoke specific emotions.

"Everything that you went through, positive or negative, occurs in a space," says Travis. "These spaces get into memories and they begin to tag and inform your perception of the world."

Psychologist Sam Gosling at the University of Texas has visited some of the homes Travis has designed and spoken to the owners. They have told Gosling that they wouldn't change a thing about their home and that it has never felt so comfortable. Travis also finds that his first drawings hit the mark with his clients. Even so, they find it hard to acknowledge that their home knows so much about them. "They still resist the idea that it was their psychology that had anything to do with driving the design," says Gosling. ➤

Cold front in the kitchen

It's easy to think of our homes as monolithic structures with uniform climatic conditions throughout, but that couldn't be further from the truth. Different rooms, even different parts of the same room, have their own temperature, humidity and light levels. Your house has its own weather.

Temperature differences of 40 °C between the coldest and hottest places in the house are not uncommon, says Richard Corsi at the University of Texas, who has spent two decades studying indoor air quality.

Many of the changes to the indoor weather are what you would expect. Switching a radiator on or sunlight shining through a window will increase temperatures. And temperature differences across your home drive indoor airflow. "If the air is really hot

"Parties in your home create their very own meteorological effects"

in the basement in the winter and cooler in the occupied space, the warm air is going to move towards the cool air," says Corsi.

But some of the indoor weather patterns are far less obvious – and we are responsible. "All of us are 60 to 100 watt light bulbs, depending on our size," says Corsi. Our warming of the air around us can take on particular significance when everyone congregates in a room at a party. "Warm air rises from us towards the ceiling and tends to bring in cooler air from elsewhere in the room to replace it. So you have these circulatory patterns of air rising and falling," says Corsi. The parties in your home don't just go with a bang, they create their own meteorological phenomena.

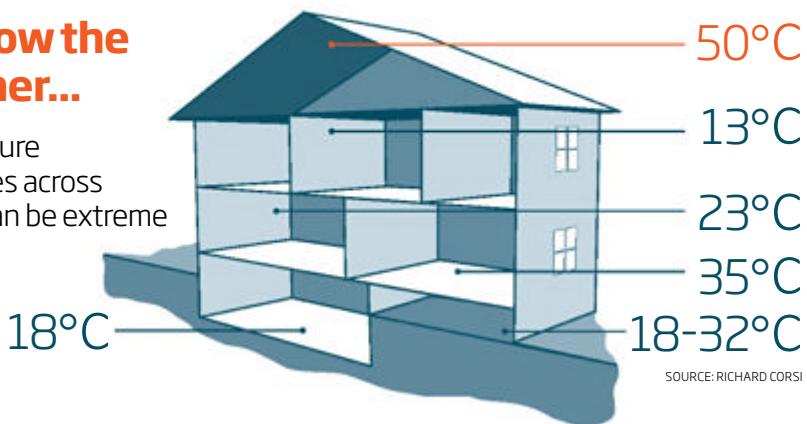
Just as the planet has extreme weather, so do our homes. The most extreme conditions are in places we don't see, such as the attic and the spaces within our walls. "If a house has air conditioning, then the coldest place in the summer will be about 12 °C in the air that's flying from the supply duct," says Corsi. "In the occupied spaces it might be 23 °C, and external wall cavities and attics can get up to 50 °C." It doesn't just get hot. When the sun beats on an external wall, it raises the pressure in the cavity between outside and inside. Walls aren't just walls, they are frontal systems too!

BERNDNAUT SMILDE/NIMBUS, 2010. DIGITAL TYPE PRINT 75X112CM COURTESY OF THE ARTIST AND RONCHINI GALLERY, LONDON, UK



And now the weather...

Temperature differences across a home can be extreme



SOURCE: RICHARD CORSI

This is your life

We spend a surprising amount of time inside



78.7

years - average life expectancy



70

years spent inside buildings



50

years spent in residential buildings



26

years spent lying on a mattress



2bn

the number of buildings thought to exist in the world, although no one knows for sure



\$20tn

the value of residential building stock in the US - making it the country's number one asset

Indoor chemistry

Every moment of every day, chemical reactions are taking place in the air and on almost every surface of our homes. The primary driver of this indoor chemistry is ozone, a highly reactive molecule made up of three oxygen atoms. Most of it comes into our homes from outside, although relatively small amounts come from air purifiers, laser printers and heating, ventilation and air conditioning (HVAC) systems.

It doesn't hang around for long. "Indoor ozone tends to be much lower concentration than outdoor ozone, but that's because it reacts with so many things indoors," says Richard Corsi at the University of Texas. "So there's a lot of interest in ozone reaction products."

Ozone reacts with anything scented, such as air fresheners and cleaners. "All of those scented compounds have carbon-carbon double bonds and ozone loves to attack those things," says Corsi.

The proliferation of fragrances in our homes means that, in some cases, the chemistry is unknown. "We are using so many scents indoors these days and when they oxidise they form things we just don't find outdoors," says Corsi. "No one has done the toxicology on them." He says we should be paying attention to peroxides and dicarbonyls because they have a similar structure to other chemicals known to be toxic or cause severe irritations. "There are red flags flying all over the place," he says.

Ozone attacks the carbon-carbon double bonds elsewhere too – in the styrene in our carpets, in our soaps and even in the oils on our skin. It leads to the formation of carbonyls, including formaldehyde, the pungent gas used as a preservative in mortuaries. "In high enough levels it can cause upper respiratory problems and eye irritation, that kind of thing," says Corsi. Other short-lived molecules called Criegee biradicals are also produced by ozone chemistry. These are extremely reactive and lead to the formation of a wide range of by-products, including some that are irritants or toxic.

A move towards greener living doesn't help. Many "natural" cleaning products contain terpenes or terpenoids, organic molecules found in plants that are highly reactive with ozone. "Tighter, more draft-resistant homes and more green products have led to our homes becoming intense chemical reactors," says Corsi.

NOT SO FRESH AIR

Three unexpected pollutants

DISHWASHERS:

Dishwasher detergent can contain sodium hypochlorite and when it reacts with some foods, particularly meat and tomatoes, the result is chloroform.



SCENTED CANDLES:

The slow-burning scenting agents only have a millisecond to burn in the flame and often don't burn completely. Many lead to the formation of ultra-fine particles that can find their way into our lungs.



VACUUM CLEANERS:

The wheels flick up particles that contain allergens and pollutants into the air.



Many indoor pollutants are released into our homes by the things we bring into them. Formaldehyde, for example, comes from the likes of plywood and cosmetics. There's also the release of semi-volatile organic compounds, such as the flame retardants used in furniture and bed mattresses.

However, certain materials soak up what's been released and the products of indoor chemistry. "The polyurethane foam that's often used in furniture and as foam padding beneath carpet is a tremendous sink for pollutants," says Corsi. As is the gypsum plasterboard that lines many of our walls.

The weather inside our homes (see "Cold front in the kitchen", left) has a big impact on pollution levels. The high temperatures sometimes found in the spaces between walls speed up the rate of chemical reactions. "As a really rough rule, if you increase the temperature of a material by 10 °C, you are going to double the emission rates from it," Corsi says. And when the temperature rises, so does the pressure in the spaces – pushing the dirty air into our rooms. "Electrical outlets and cracks in the walls are really leaky," says Corsi.

Home but not alone

Every nook and every cranny of our houses and flats is an invisible ecosystem of bacteria, fungi and archaea. And it's only now that we are beginning to get a true picture of this ecosystem.

Biologist Rob Dunn at North Carolina State University in Raleigh has conducted the biggest study of domestic microbial ecosystems to date. His team is sequencing the DNA on swabs sent to him by volunteers from 1430 houses and apartments across North America to identify what's living on door frames, pillows and kitchen counters. "Some live with goats, some live in fraternities with 40 other dirty stinky guys, some live with kids," says Dunn. Every single one has microbial DNA on every surface we swabbed."

Dunn and his team discovered phenomenal diversity amongst the microbes. To sequence the full genomes of every beastie would have been impossibly slow. So Dunn's team analysed sections of DNA and classified the microbes into loose categories known as operational taxonomic units (OTUs).

The results were still surprising. They found 75,000 OTUs of bacteria, 35,000 OTUs of fungi and 350 OTUs of archaea across all the

investigated the bacteria on floors, desks and chairs in a university classroom and says the results apply to our homes too. "When you look at the bacteria on the seat of a chair, it's not just skin-associated bacteria, there's also stuff associated with the human gut and the vagina," says Meadow. "Whether we like to admit it or not, we're incredibly leaky animals and our clothes are definitely not the impermeable barrier we like to think they are."

While some bacteria are widespread, there are also geographic variations. Dunn's team has found some plant pathogens only in houses in corn-growing regions. "We're seeing this really beautiful replication of everything biologically that's going on around us seeping through our windows into our homes," says Dunn. There are also differences within each home based on the climatic conditions we create in each room and what we do there.

The effect of all these microbes we share our rooms with is far from clear. "There's been a lot of research into the bad things, the pathogens," says Meadow. "But the majority of microbes have no impact on our health or a positive effect." While research into the health effect of the microbial ecosystem is still at an early stage, one study carried out in 2013 gives an insight into its influence. Mice exposed to dust from homes with dogs were less likely to develop asthma than mice exposed to dust from dog-free homes. The protected mice were found to have higher levels of the bacterium *Lactobacillus johnsonii* in their intestines, which appears to somehow dial down their immune systems.

We are also pretty ignorant of the effect we are having on our home's microbes too – especially when it comes to cleaning with bleach and other products. "We're choosing the ecosystems we have around us and mostly we're doing it pretty blindly," says Dunn. "We go to war against these invisible lifeforms and we think we're creating an environment that's free from them. Instead, we're creating an environment in which we favour those few species able to withstand our assaults."

Dunn hopes further research will show us how to "garden" our home's microbial ecosystems so they contain the right mix of species to keep us healthy. "It's stupid not to," he says.

Andy Ridgway is a science writer in Bristol, UK



"Chairs hold bacteria from the human gut and vagina. We are leaky animals"

homes. "With the fungi, that's of the order of magnitude of all of the named fungi on Earth. It's astonishing really," says Dunn.

His team went on to study a subset of homes in more detail – and found much, much more. "There was a couple of thousand kinds of arthropod in houses and they include amazing things," says Dunn. Among them is the drain fly, which inhabits many kitchen drains and whose larvae live off the waste at the bottom. "We also found a parasitoid wasp in almost every house," says Dunn.

The microbes we shed from our skin, such as *Staphylococcus* and *Corynebacterium*, live in every room in our homes. "Everyone tends to worry about the toilet seat but the truth is that everywhere we put our bodies tends to have a set of 'you' microbes," says Dunn.

This is borne out by other research. James Meadow at the University of Oregon in Eugene

Location, location

Some of our house mates also have



INDOORS

Hot water heaters and kettles

OUTDOORS

Hot springs around the world

SHARED SPECIES

Bacterium *Thermus aquaticus*



CLOCKWISE FROM TOP LEFT: CLAUDIO REHM/PLAINPICTURE; SARAH SMAIL/GETTY; CRISTINA PEDRAZZINI/GETTY; PEOPLEPICTURES/GETTY



Is your toaster spying on you?

A smart toothbrush that tells you how you are brushing. A thermostat that lets you control the temperature of your home when you are out. A slow cooker that alerts you when dinner is ready.

More and more of our gadgets are connecting to the internet, letting us interact with our homes from afar. They promise to save us money and improve our health. But are they opening the door to third parties like power companies and Google? If so, the secrets of the home may not be secret for much longer.

"With a smart system, the whole point is that when you use it, it learns about you over time," says James Scott of Microsoft Research in Cambridge, UK, who designs smart home gadgets. "That learning intrinsically involves some sort of logging."

This is essential for the device's makers to provide the brains behind the service, which may depend on artificial intelligence running on servers on the other side of the world. It's an area fraught with privacy issues, says Scott.

The list of domestic appliances now vying for data about your home life is expanding considerably. Google's Project Tango, for example, allows smartphones to scan indoor environments, potentially allowing developers to build up a database of maps of indoor locations – including our homes. All data also goes to Google, of course.

"The reality of the home as a private place is being overturned," says Lee Tien, a senior

staff attorney at the Electronic Frontier Foundation, a civil liberties group based in San Francisco. "But our sense of it as private may not be."

This, he explains, is where the danger lies – a false sense of privacy. Homes may become less and less private, but their occupants aren't necessarily aware of this and so aren't disposed to change their behaviour when inside them.

And why should we? Much depends on who is doing the watching. Early adopters of smart home tech may be the elderly. Devices that monitor and learn a person's normal

"More and more domestic appliances are vying for data about your home"

routine, then raise an alarm as soon as they detect something unusual, could let people live in their own home for longer.

Greenpeak's "Senior Lifestyle System" shares information about an older person's activity in their home with younger members of their family, for example. For some, losing a little privacy might be worth it if it means keeping their independence for longer.

Not all systems are targeted at the elderly. Xetal's MoCa uses wall mounted devices to tell homeowners how many people are in each room. The system also tracks inhabitants' movements, revealing when they are out or watching TV.

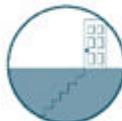
The concern is that smart homes will provide companies with yet another means to snoop. Devices that monitor energy usage in our homes could be used to build up a profile of who lives there. Peaks in energy consumption might show which religious festivals they observed, for example. It is even possible to detect when a washing machine is on rather than the TV since they have different energy signatures. And researchers have shown that energy signatures can even be used to tell what film was being watched.

We may need to get used to the idea of no longer being home alone. ■

residences in the great outdoors



Dishwasher



Basements



Bathroom



Tap water

Faeces of fruit bats

Caves

Fungus *Exophiala dermatitidis*

Camel crickets and silverfish

Forest dung pile

Ponds

The bacteria *Lactobacillus johnsonii* and *Lactobacillus acidophilus*

Copepods and rotifers

Chris Baraniuk is a writer in London

ANGELS OF DEATH

Fish thieves, riverbank wreckers, alien invaders. Cormorants are despised and persecuted - but for no good reason, says conservation biologist **Linda Wires**

IN JULY 1998 I visited Naubinway, Michigan, for the first time. The town is one of the state's few remaining commercial ports and fishing is the mainstay of its economy. But I wasn't there for the fish. I was headed for a small island about a kilometre offshore, uninhabited by people but teeming with bird life in the summertime.

Herring gulls and double-crested cormorants begin nesting in this part of the Great Lakes in May, and by mid-June there are thousands of chicks. I went there with my University of Minnesota colleagues Francie Cuthbert and Dave Smith as part of a study of cormorant population dynamics. I didn't know it then, but it was the beginning of a journey that would shape much of my life.

That year, low water levels had made the public jetty inaccessible, so we drove to the one used by commercial boats. Two fishermen watched us as we pulled up. Dave asked them if it was OK to use the jetty.

"What do you want to do out there?" the older man asked. Francie explained that we were conducting research on cormorants. The man nodded. "Yeah, those birds are causing lots of trouble. Something needs to be done if we're gonna fish here."

"Fishing bad?" Dave asked. The younger man snorted. "Real bad. Won't be no fish left soon. Gotta do something about those birds."

"Is your research gonna help?" the first man asked. Francie answered that it might help us understand the population better. The men looked sceptical, but gave their permission. As we put in, Francie told them we wouldn't be

on the island long. The younger man smiled. "Take your time. Get as many cormorants as you can. We won't tell."

It took only minutes to reach the island but it was as if the journey transported us to another world. As we approached, the cormorants took wing in a thunderous rush while the gulls swooped and shrieked overhead. The desolation of the island and the wildness of its inhabitants had an extraordinary effect on me. Though I had encountered cormorants many times before, seeing them in such numbers made me feel like I was experiencing them and their world

for the first time. Since then I have visited many cormorant colonies, and come to realise that this bird is one of the most remarkable creatures I have ever encountered.

The same year I took that trip, two events occurred that would affect cormorants across North America for years. In March, the US Fish and Wildlife Service published a "depredation order" allowing fish farmers to shoot an unlimited number of cormorants without a permit. The order covered 13 states, 12 of them in the south-east, where catfish ponds are abundant and hundreds of thousands of cormorants overwinter. By the end of 2010, an estimated 300,000 cormorants had been killed under the order.

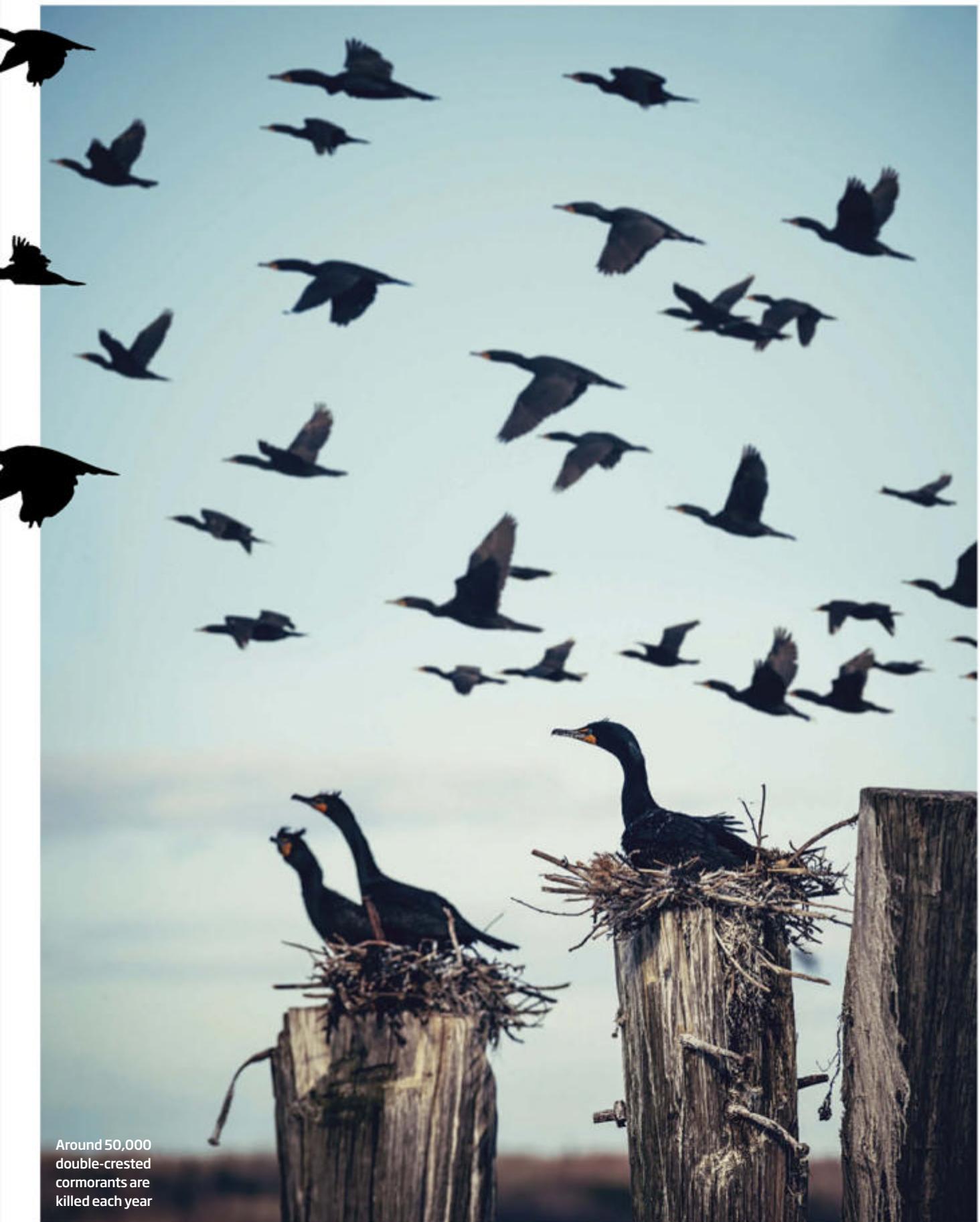
The second event was a vigilante-style slaying of double-crested cormorants at Little Galloo Island in Lake Ontario, which at the time supported some 8500 pairs, the largest known colony in the world. In July, biologists made a routine visit to the island and encountered a grisly scene: more than 800 dead, decaying cormorants and piles of shotgun shells.

Months later, nine men, many of whom were fishing guides, pleaded guilty to killing the birds. They were fined and sentenced to house arrest, but the incident was likened to the Boston Tea Party and the men attained local hero status.

This incident brought the cormorant "problem" into sharp focus for the Fish and Wildlife Service, culminating in 2003 in a second depredation order covering 24 states in the eastern US and allowing the killing of



JOEL SARTORE/NGS



Around 50,000 double-crested cormorants are killed each year

SHAUN/GETTY

"Their fishing talent is a double-edged sword, as it brings them into conflict with humans"

any cormorants deemed to be a threat to public resources, including fish, wildlife and land. By the end of 2011, this had resulted in the death of around 146,000 birds and the destruction of countless numbers of nests and eggs, mostly in the Great Lakes region. Thus began the modern American war on cormorants.

To begin to sense the injustice of this war, one must first understand just how extraordinary cormorants are. Consider their occurrence at Disko Bay in Greenland, where glaciers and icebergs abound. Most of the region's animals are insulated from the cold by dense coats of fat, fur or waterproof feathers. All, that is, but for the great cormorant – the most widely distributed of the 40 or so species worldwide – which survives year-round in this frozen landscape despite lacking a substantial fat layer.

Not only does the cormorant survive, it thrives. Its fishing performance is the highest ever recorded for a marine predator. How do cormorants – which originated in the tropics – manage to live so successfully in the high

Arctic? The answer lies partially in their exceptional plumage.

Cormorant feathers are unique amongst birds that hunt underwater, with an outer, wettable section and an inner, waterproof one. This confers two advantages: the outer section soaks up water, reducing the cormorant's buoyancy, while the inner section retains an insulating layer of air against the skin. The result is a bird that can dive and pursue fish in a range of water depths and temperatures.

The eyes have it

This balance between buoyancy and insulation is just one of many unique adaptations. Another is their eyes. Not only are these often described as among the most beautiful of all birds' eyes, they are also functionally remarkable. The unusually flexible lens changes shape extremely rapidly, while the muscles that regulate pupil size also act on the lens. These features presumably help cormorants find and catch fish underwater.

Yet how much the cormorant relies on vision isn't clear. They hunt successfully in turbid waters and throughout the dark Arctic winter. So their hunting prowess must also depend on artful strategy, or some other adaptation as yet unknown.

Humans noticed this remarkable fishing skill a long time ago. For more than 2000 years, people in China have been taming cormorants and training them to bring back fish. This style of fishing is still practised in some parts of Asia.

Alas, the bird's fishing talent is a double-edged sword, for it is this that brings it into direct conflict with humans. As a result, many cormorant species have been, and continue to be, persecuted in many parts of the world. In Europe, the great cormorant was almost hunted to extinction in the 19th century and



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is still widely culled. In Australia and New Zealand, many species have been intensely persecuted.

In North America, the persecution falls almost exclusively on the double-crested cormorant, the most common and widely distributed of six native species. In recent years, millions of US and Canadian dollars have been spent on reducing its numbers, based on a perception that it is the most significant bird predator on fish in North America.

The double-crested cormorant is certainly an efficient and adaptable predator, capable of exploiting a range of habitats from coastal bays to inland waterways. More than 60 families of fish have been documented in its diet. When birds are shot and their stomach contents examined, large numbers of intact fish are often observed, which only reinforces their reputation as voracious eaters.

Cormorants are also powerful agents of environmental change. Through their nesting and roosting habits – they are equally at home on the ground or in trees – they can denude a landscape of vegetation and cover it in guano. They can also defoliate and ultimately kill the trees they nest in. This destroys habitat for some groups of birds, though it creates it for others.

Breeding colonies can build up to tens of thousands of birds filling every available space; occasionally, cormorants are observed nesting on top of dead cormorants. Guttural grunts, raucous calls, gargles, hisses and whines provide constant background noise and further amplify the impression of numerical greatness. Approaching such a

ARISTOTLE'S RAVEN

The persecution of cormorants can be traced to antiquity. Around 350 BC, Aristotle wrote his influential *History of Animals*. In it he identified the cormorant by a name that would haunt it for centuries: *hydorokorax*, or water raven.

To Ancient Greek sensibilities this would have been highly significant. Birds were an important source of omens; certain birds were considered more ominous than others, and the raven was regarded as one of the most ominous of all.

Taxonomists recognised the difference between ravens and cormorants long ago. But the essential qualities that linked these birds in Ancient Greece continue to link them today. The cormorant resembles the raven in looks and sound. Its sombre black coat, combined with its sinister demeanour, infuses it with a certain ominous aspect, and it persists as an evocative figure of power and ill repute.



ARTO HAKOLÄ/GETTY



The legendary hunting skills of cormorants have long been exploited by us

ball park as the total number of birds killed in the worst environmental disasters. The Exxon Valdez oil spill, for example, killed somewhere between 250,000 and 580,000 sea birds. The number of double-crested cormorants killed since 1998 is well over 500,000.

However, the extent to which cormorants actually harm human interests is unclear. Some prey species are commercially valuable, but the bulk of the cormorant's diet consists of species not valued by humans. And despite its reputation for devouring fish, its daily food consumption relative to body mass is no greater than that for other fish-eating birds. To date, no study has demonstrated that cormorants pose a threat to the survival of healthy fish populations in natural systems.

To the agencies managing cormorants in the US, this is inconsequential. Scientific proof of impacts isn't a required component of the regulations for management. Nor has there been any consideration of ethical dimensions.

The western front

To the extent that the agencies employ data, it is to argue that the number of birds destroyed is inconsequential relative to the total population. This is arguably true. An annual cull of 40,000 to 50,000 double-crested cormorants represents less than 5 per cent of the North American population. Clearly, the species isn't in any imminent danger of being culled to extinction.

But is this the only criterion by which the efforts to suppress cormorant numbers should be judged? Half a million of anything is a large number. In addition, millions of dollars have been spent to sustain the effort, with little evidence that it does any good.

Nonetheless, the war on cormorants continues. Record numbers were killed in Michigan in 2012, and Minnesota expanded operations in 2013. The Great Lakes Restoration Initiative – a huge project to reverse decades of environmental degradation – has identified their destruction as an essential measure, on a par with cleaning up toxic substances and combating invasive species. Last August, both depredation orders were extended for another five years.

The war is also expanding westwards. In 2012, the Pacific Flyway Council, which coordinates the management of migratory birds in western North America, proposed managing cormorants to address conflicts over fish resources. And in 2014, the US Army Corps of Engineers proposed killing thousands of cormorants on the Columbia river estuary

on the Oregon-Washington border, to protect commercially valuable juvenile salmon and trout. If carried out, this would be the largest cull to date.

Yet there are also glimmers of hope. Scientists are increasingly questioning cormorant control in the scientific literature, in their comments on cormorant

"The reek of guano and rotting fish is detectable from quite a distance"

management plans, and in popular books. Encouraged by these moves, the US Center for Biological Diversity and other wildlife organisations petitioned the Obama administration to reconsider the routine use of lethal force to manage "nuisance" wildlife including cormorants. More recently, Public Employees for Environmental Responsibility, a non-profit group that aims to improve management of public resources, has mounted a legal challenge to the renewal of the depredation orders.

In Canada, cormorants are culled to a much lesser extent and there is a greater willingness to use non-lethal methods. The largest colony in eastern North America, just outside downtown Toronto, is managed by deterring cormorants from nesting in trees or in sensitive areas. Efforts are also made to increase appreciation of the cormorant colony as a spectacular natural phenomenon in the heart of an urban wilderness.

I hold out hope for cormorants. As more information becomes available to dispel the myths and misconceptions about these birds, understanding, tolerance and even appreciation for them will increase.

Ultimately, the cormorant's story reflects a culture still deeply prejudiced against creatures that exist outside the boundaries of human understanding and acceptance. To determine wildlife policy for these and other such creatures in the absence of scientific evidence is deeply flawed. I hope that by telling the cormorants' side of the story, I can help to encourage a more nuanced and humane approach to this unique and fascinating family of birds. ■



TESSABUNN/IN PICTURES/CORBIS

colony from downwind, the reek of guano and rotting fish is detectable from quite a distance.

These attributes inspire fear, disgust, anger and hatred. Cormorants are often described as "invaders" in regions in which they are actually native, and are often considered "overabundant", even when they occur in relatively moderate numbers. For centuries, humans have gone to great lengths to destroy cormorants. Adults are usually shot and eggs are coated in oil, which asphyxiates the embryo but tricks the parents – which normally re-lay if their eggs are destroyed – into incubating eggs that will never hatch.

The depredation orders opened Pandora's box, and those authorised to kill cormorants took extraordinary liberties. To grasp the magnitude of the persecution, consider that the number of cormorants legally destroyed in the US between 1998 and 2011 is in the same

Linda Wires is a conservation biologist at the US Fish and Wildlife Service in Bloomington, Minnesota, and author of *The Double-Crested Cormorant: Plight of a feathered pariah* (Yale University Press)

To have and have not

The story of junk DNA is curious, controversial and complex, finds **Linda Geddes**

Junk DNA: A journey through the dark matter of the genome by Nessa Carey, Icon Books, £18.99



SNOW WHITE, the six-toed cat famously given to Ernest Hemingway by a ship's captain, did not get its extra digit as the result of a freak gene mutation.

In fact, extra fingers and toes in both cats and humans result from alterations in junk DNA – the 98 per cent of the genome that has no genes, doesn't code for proteins, and which was until recently dismissed as, well, junk. In the case of extra digits, a piece of regulatory DNA has mutated, "enhancing" the activity of a gene crucial to the development of hands and feet.

That's not so different from the conventional explanation of how the genome works – more a small tweak in our understanding – but it's just the start of junk DNA's weird and intricate story. From "sleeper agents" that used to be viruses to reading genes backwards, Nessa Carey's book, *Junk DNA*, guides us through this dark side of the genome. And it's a side that is turning out to be full of strange twists and turns.

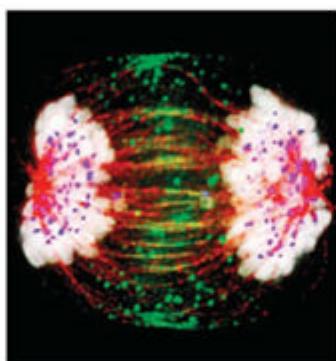
It's a formidable subject, but one that Carey, a former senior lecturer in molecular biology at Imperial College, London, is completely at home with. She does a great job of describing the politics of this controversial field. "At one extreme," she writes, "we have scientists claiming

POPPERFOTO/GETTY BELOW: DR PAUL ANDREWS, UNIVERSITY OF DUNDEE/SPL



experimental proof is lacking to support sometimes sweeping claims. At the other are those who feel there is a whole generation of scientists (if not more) trapped in an outdated model and unable to see or understand the new order."

And Carey's use of analogy to explain molecular phenomena is



Chromosome division: like two tiny Spider-men at either end of the cell

Thanks to junk DNA, one of Hemingway's cats had an extra toe

superb. For example, she provides the most original explanation I've read of how chromosomes segregate in cell division. She describes them as two tiny Spider-men standing at either end of the cell, shooting sticky webs to pull what they want towards them. The downside is that such lovely analogies are often followed by jargon-heavy explanations of the details of the process.

Junk DNA is encyclopaedic: from enhancers to insulators to lncRNA, this book has it covered. And if you are someone who already knows what those nouns and acro-nouns mean, you will find the book a comprehensive and accessible review.

However, Carey claims her book is aimed at general readers and it does read a little like a textbook for laypeople (complete with uninspiring diagrams). You have to wonder how many of them would actually want or need such a comprehensive understanding of the field. Carey might have been better off exploring fewer types of junk DNA, but with greater colour.

Junk DNA also lacks an overarching, compelling narrative to carry readers through, and is

"From viral sleeper agents to genes read backwards, it's a tour of the dark side of the genome"

short on personal stories to help them engage. For instance, it starts and ends with the mystery of facioscapulohumeral muscular dystrophy (FSHMD), an inherited wasting disorder in which muscles of the face, shoulders and upper arms weaken and degenerate.

This is a fantastic example of how junk DNA becomes implicated in disease. A change in the number of repeating sections of a piece of junk DNA causes a "retrogene" to be activated, but only in the presence of another junk element and a pattern of specific chemical – or epigenetic – changes. Yet without a character to bring the disorder to life, FSHMD remains obscure and unpronounceable.

But if you are motivated to read on regardless, *Junk DNA* provides a cutting-edge, exhaustive guide to the rapidly changing, ever-more mysterious genome. ■

Linda Geddes is a science writer

Burdened by the brain

Tom Stoppard's new play loses its way, says **Rowan Hooper**

The Hard Problem by Tom Stoppard, National Theatre, London, from 21 January, and live in some UK cinemas

AS I got up to leave at the end of *The Hard Problem*, a man in the seat behind me was behaving rather strangely. Weeping and smiling at the same time, he was clearly undergoing some profound form of conscious experience.

Well, what a bit of luck for a reviewer. Here, under my nose, was a demonstration of the so-called "hard problem" of consciousness. Physical processes – sound and light – were entering the man's ears and eyes and combining in some way in his brain to produce subjective feelings only he could experience.

But why? Why do we experience things at all? This is the hard problem coined by the philosopher David Chalmers in the 1990s, and it is ostensibly the subject of Tom Stoppard's first new play for years.

In the case of the emotional man, the answer turned out to be simple, on one level. He was the father of actor Olivia Vinall, who had been fabulous, pretty much carrying the play. This was a display of overwhelming pride in his daughter's performance.

Explaining consciousness for real is tougher, of course. But what was irritating about *The Hard Problem* was in fact the weight it gave to the hard problem. A good many neuroscientists and philosophers, for example Patricia Churchland or Giulio Tononi, now think it is overblown.

To me, the hard problem has a whiff of anti-science about it, since it argues that we will never be able to explain conscious experience.



ELLIOTT FRANKS/EYEVINE

Ladlefuls of science, but it's tough to wring empathy out of the lines

Indeed, the feeling that some things defy explanation pervaded the play. One character even resorts to Hamlet's tired "there are more things in heaven and earth" line. This wouldn't matter if there was a thrilling narrative or we felt empathy with the characters, but these were sadly, and surprisingly, lacking.

I had been looking forward to this play. Stoppard's masterpiece, *Arcadia*, uses science – particularly physics and mathematics – to infuse and inform a deeply affecting and profound script. There his touch is sublime, but the new play serves up science in ladles. Some parts feel like slightly wittier rewrites of textbooks or student debates: not what we expect from a master like Stoppard. All smart stuff, but not very dramatic.

The story follows Hilary (Vinall), a young Christian psychology student hoping to land a PhD position at a

prestigious institute. Her tutor Spike (Damien Molony) is a kind of caricature of Richard Dawkins, though significantly more buff.

Most of the play turns around these two, as Hilary puts forward traditional arguments against a materialist explanation of the world, and Spike caustically rebuts them. Raphael's *Madonna*

"Some fear we lose something by reducing our inner lives to blobs on a brain scan. I think we gain"

and *Child* is, he says, better named "woman maximising gene survival". It's funny, but it seems as if Stoppard is trying to say that scientists can't appreciate art.

There is a great anti-science rant in *Arcadia*, but that play still leaves you amazed, feeling that you have had a glimpse into the profound secrets of the universe. It's different with *The Hard Problem*. We don't make much emotional connection with the characters, apart from Hilary, who has a moving subplot about a

daughter she gave up for adoption.

The attacks on science are unnecessary and ill-formed. "Where in the brain is metaphor happening?" asks Hilary. "Where is accountability and free will?" These don't show up in an fMRI scan, she says. In fact, metaphor may well show up in scans, as do all sorts of aspects of our inner lives. Some people fear we lose something if we reduce such aspects to blobs on a brain scan. I think we gain.

Stoppard seems to channel the philosopher Thomas Nagel, who asserts that mental processes are different from physical ones, so are not subject to natural selection. To many, this opens the door to the supernatural. In short, Stoppard is worrying about issues that I don't think are problems.

Stoppard once said that he has no interest in educating his audience about science. Perhaps he has become more interested in alerting his audience to what he sees as science's limitations – and that's a great shame. ■



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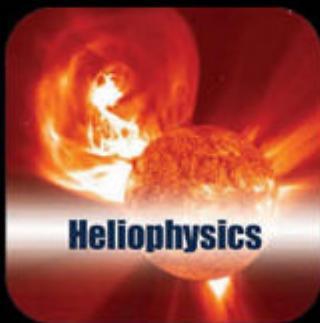
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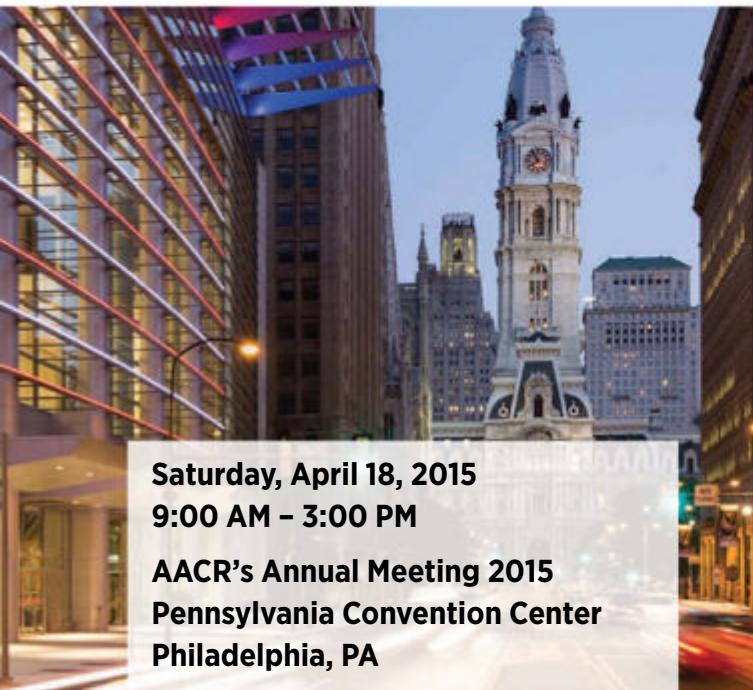
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The monoverse

From Ken Pettett

I was extremely pleased to read Lee Smolin's article on the multiverse (17 January, p 24) – it's nice to know that I am not the only person who thinks parallel universes should be confined to speculative fiction.

I am, however, puzzled by his proposed "principles". They look remarkably like axioms. In particular, the second, "that time is real", presents problems. Cosmologists appear to discuss at least three levels of existence: not existing, existing and "really existing". For example, they often ask questions along the lines of: "we have detected the so-and-so particle, but does it really exist?"

Would it be possible for cosmologists to define these three properties? While they are at it, perhaps they could clarify their claim for an infinite number of universes: which infinity do they mean, and why?

Sandy, Bedfordshire, UK

From Peter Micklethwaite

Lee Smolin asks questions about recent ideas in cosmology and how they are formed. While inevitably theoretical, cosmology eventually has to subject itself to empirical, observable reality.

My perception is that this isn't happening as much as it did. Call me old-fashioned, but I still think Karl Popper's idea of "falsifiability" remains a good standard to adhere to.

As we celebrate the hundredth anniversary of Einstein's theory of general relativity, which is arguably the most Popper-tested theory ever, one would hope science generally would prioritise empirical enquiry. But in recent years it is difficult to see this happening in a discipline I have loved since I was a teenager.

I welcome free-thinking ideas such as the multiverse. But surely science itself should be challenging the theorists

face-to-face to provide a truly testable theory, sooner rather than later. Aside from some vague possibilities, we aren't being given serious tests, and one asks: "Is this actually science?"

Petersfield, Hampshire, UK

From Vernon Barber

As a biologist I found it rather sad to read the defeatist article by Lee Smolin. If understanding the mechanics of the universe were



easy it would have been worked out years ago. Doesn't he see that it is likely to be the ultimate puzzle to solve in science?

We do have one clue: the universe we inhabit has allowed life to originate and, in one case we know of, a species has evolved that should ultimately be capable of fully understanding the universe and its workings.

If, however, studies of the universe show that there are a large number of anomalies that cannot be reconciled, this might suggest that we are "living" in a vast, complicated "computer game" which isn't fully internally integrated.

Westcliff-on-Sea, Essex, UK

Glasgow's failure

From Jan Karpinski

The connections drawn by Harry Burns between public health, child development and social welfare are important and deserve respect (24 January, p 26).

However we should not accept

the narrative that attributes poor public health in Glasgow to the de-industrialisation of the 1970s and 1980s. Shipbuilding and steelmaking were physically hard and hazardous occupations. They may have provided a living wage, but it is difficult to see them as a source of general joy, health and well-being.

De-industrialisation has contributed to, rather than detracted from, better public health throughout the UK. The question is why Glasgow has reaped fewer benefits and suffered more detriments from de-industrialisation than any other city in the UK (and possibly any other city in Europe).

It is now over 30 years since Glasgow's reinvention as a tourist destination under the "Glasgow's Miles Better" campaign, and exactly 25 years since it became the UK's first European Capital of Culture.

If lack of a sense of purpose is the problem in Glasgow, why has it failed to find a new one? Perhaps the root causes of Glasgow's low life expectancy are as much anthropological as economic or political.

Shepton Mallet, Somerset, UK

Costing carbon

From Brian Wall

Fred Pearce worries that falling fossil fuel prices may discourage investment in alternative energy sources (17 January, p 22). But can we exploit falling oil and coal prices to encourage investment in renewables?

Consider an international agreement fixing the price to the retailer of each fossil fuel type at its present level. When the producer's price falls further, the gain made by the wholesaler can be remitted to the state, and this surplus can be used to subsidise the purchase price of renewables.

This could be a golden opportunity to introduce a mechanism with the same effect

as a carbon tax, which is painless to the consumer and supports sustainable energy production.

Glengarriff, Ireland

Evolution made easy

From John King

Colin Barras's article on plasticity proposes that advantageous behaviour can persist until a compatible mutation makes it permanent and a base for further change (17 January, p 26).

For a long time I have struggled to see how evolution could have worked in the limited time available. Conventional thinking requires each evolutionary step to be a coincidence of two unlikely events: a genetic mutation and a change of behaviour. In the period between one and the other, no benefit and some disadvantage is usually on offer.

Plasticity is one of those light-bulb ideas which explain so much; once recognised it seems obvious, and we are left wondering why we hadn't thought of it before.

Wymondham, Norfolk, UK

Nuclear betrayal

From Andrew Irvine

You described the UK as "rushing to build" its nuclear weapons and facilities (24 January, p 5). The reason for this was treachery from our ally, the US.

At the end of the second world war, the US passed a law forbidding the sharing of nuclear technology with any other nation. This was manifestly unfair to the UK, which during the wartime years had generously shared its technology, including nuclear science and engineering.

The UK government had a stark choice: build our own, or lose all influence internationally. When the US government realised that we were going nuclear, the UK was threatened with withdrawal of aid and threatened in the way that

rogue states are nowadays.

This distrust made it all the more important to proceed, especially when the USSR showed its own nuclear capability. France developed its nuclear programme separately from the US, and still keeps it separate; it was less trusting than the UK, and may have been right.

Walsall, West Midlands, UK

Musical monkeys

From John Davenport

Hal Hodson points out that the "speech" of great apes is limited to discrete sounds (10 January, p 39). They don't have the vocal flexibility of gibbons, which are able to "sing" a greater degree of meaning into their sounds.

Perhaps the apes' problem isn't with their vocal cords but with their ears. If you are tone deaf then one woo-hoo sounds much like another. Has anyone ever tried singing to apes? Perhaps a musicologist could help investigate what the apes can distinguish.

Kenley, Surrey, UK

Don't halve a cow!

From Anthony Oke

One of the graphics accompanying Linda Geddes's article on red meat gave the percentage of various animals that is edible (24 January, p 30). It indicated that only 40 per cent of a cow could be eaten. But in a less

wasteful society most of it is eaten, as it used to be in the UK.

The skin, if not turned into leather, can be treated and used like pork crackling. The stomach can be eaten as tripe. The intestine is still eaten widely in West Africa, where I come from. Offal is sought after. We boil the feet, without muscle, to make stock.

The bones are ground into powder, making thickeners for food. Even what remains – horns and hair – can be turned into buttons, oil and absorbent materials. Less than 10 per cent of a cow is inedible, and none need be wasted.

Stafford, UK

Whale of a brain

From David Evans

The review of the book *The Cultural Lives of Whales and Dolphins* has whetted my appetite (10 January, p 43). It acknowledges that "sperm whales have the largest brains on the planet" but goes on to say that "relative to body size, the brains of dolphins are second only to humans".

Why is the assumption that relative brain size is important so common? Is it designed to place humans in the best possible light? If one thinks of the brain as a computer, it seems less than obvious that it must be sized in proportion to the body it lives in.

Why, for example, should a whale need an especially large brain when a hummingbird – which has complex tasks to perform – gets by with a tiny one? I would love to know.

Llanelli, Conwy, UK

Babies' babble bath

From K. Leenders

Aviva Rutkin reports that "by the age of 3, children from affluent families have heard some 30 million more words than their impoverished counterparts" (29 November 2014, p 14).

If they are awake for 12 hours a day, that amounts to 38 extra words a minute, every minute. Add the words an impoverished child hears, and they could be hearing more than one word a second. That seems a very high number. Any error?

Den Haag, Netherlands

The editor replies:

■ The figure was an estimate calculated by researchers Betty Hart and Todd Risley and assumed a 14-hour day. In their 1995 book *Meaningful Differences in the Everyday Experiences of Young American Children*, they note that, "even if our estimates are too high by half, the differences... are so great that even the best of intervention programs could only hope to keep the children of families on welfare from falling behind the children in the working-class families."

And ultimately...



From Patrick Davey

I was delighted to learn that *New Scientist* knows how to say a prayer (17 January, p 5), and even more delighted that it appears to have been heard. The same morning that I read you had offered a prayer for the Catholic church to review its attitude to contraception, I learned that Pope Francis had made comments widely interpreted as suggesting precisely that. Please try it again on other matters of importance.

Dublin, Ireland

All-natural asbestos

From Nick Thomas

In a *New Scientist* leader last year, asbestos was included in a list of "synthetic" chemicals (29 November 2014, p 3).

I am not aware of any chemical plants that synthesise asbestos, but the silicate minerals with this name have been mined for at least the last 4000 years.

The inclusion of asbestos on the list was presumably accidental, but it is still a useful illustration of the need to reclaim the word "chemical" in modern parlance.

Of course ardent chemophobes should avoid all risky chemicals by sticking to entirely natural products. For example, they could have a dinner of death cap mushroom and fugu liver risotto with a deadly nightshade side salad. They can then soothe themselves with a relaxing rub with essential oil of poison ivy. All that should go nicely with the asbestos.

Revelstoke, British Columbia, Canada

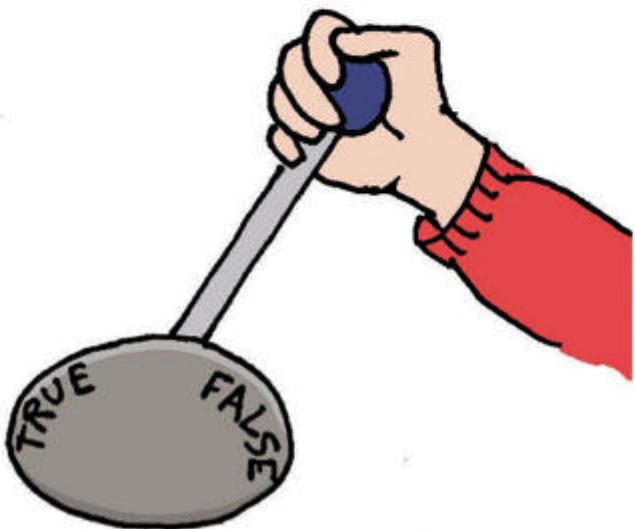
For the record

■ In our interview with NASA chief scientist Ellen Stofan (10 January, p 26), we printed a rough estimate of the distance travelled on Mars by the Opportunity rover. The latest figure from NASA is 41.8 kilometres, double the distance stated.

■ We understated the nitrogen content of Earth's atmosphere by a fair margin (24 January, p 13). It does of course account for 78 per cent by volume of dry air.

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IRREDUCIBLY SIMPLE CLIMATE MODEL

A COLLEAGUE forwards a paper with a most wonderful title: "Why models run hot: results from an irreducibly simple climate model" (doi.org/znq). The paper's authors are Christopher Monckton, with whom we have history; Willie Soon, also well known for his belief that climate change is nothing to do with us; David Legates; and William Briggs.

We had barely reached the end of the title when it occurred to us to take an information-theoretic approach. An "irreducibly simple model" would be one that is encoded by one bit of data. That one bit could represent your preconception of what the model's output should be - "true" or "false": take your pick.

The paper appears in *Science Bulletin*, whose website address is scibull.com - a choice the publishers may wish to reconsider.

NEVERTHELESS, we read the paper promising an "irreducibly simple climate model" noted above. It

states that its model – based on an equation with eight parameters and variables – is "designed to empower even non-specialists to research the question how much global warming we may cause".

This reminds us of missives we receive from people claiming to have found that the world isn't warming at all, by manipulating raw data in spreadsheets. And that reminds us that when we last mentioned that this activity has been called "mathturbation" (21 January 2012) we omitted to credit the sharp Open Mind blogger at tamino.wordpress.com.

SLIGHTLY closer to the Earth we know and love, readers continue to be inspired by the saga of plucky little lander Philae, which as we write is still shivering in a dark corner of comet 67P/Churyumov-Gerasimenko. Tim Stevenson points to something we missed in another publication's description of the cute lander having

the same weight as a newborn elephant (6 December 2014). "Philae is on 67P and all known elephants are on Earth," Tim observes. Gravity on 67P is somewhat weaker than on Earth, wherein lay the lander's challenge. So is it fair, Tim asks, to deduce that the mass of Philae "is of the order of several tens of thousands of metric tons?"

Frank Cross spotted the BBC deploying a less cuddly metaphor. Fortunately for our sanity it specified that the mass of the comet, not its weight, is "about 150,000 aircraft carriers". Would that, Frank asks, be the British vessel that has no aircraft to carry, or another one in the news?

"SHOCK" was John Rowlands's reaction to how the European Space Agency reported image ratings given by visitors to its website. The images were from the Rosetta craft, which is orbiting comet 67P, and when John looked, one image was presented with a rating of 4.818181818182 out of 5 with "11 votes cast".

"Are there now so many official websites competing for user ratings," John asks, "that we'll end up with femtoratings?" Later the same day, when we got a moment to visit bit.ly/femtorating, someone at ESA had remembered to round it off to 4.8. Well done!

THINKING of promotion, we are getting inured to reading tech jargon clichés. Occasionally, however, a press release manages to startle us back to awareness. Thus did telecoms company O2/Telefonica, hailing a device that combines "GSM 3G, Wi-Fi, Bluetooth, GPS, a pedometer and accelerometer... is voice controlled... comes complete with Instagram, Facebook, Twitter..." It "took a team of 35 engineers two and a half years to build".

Nina Bibby, marketing director, goes on: "Music and technology are in O2's DNA, which is why we're so excited to be giving O2 customers the opportunity to exclusively get their hands on the Puls in the UK... By combining cutting edge technology with music and

fashion, the Puls has the power to revolutionise wearable technology."

The list of features isn't that unusual. But – it's in their DNA? That's more intimate than wearable, surely?

RETURNING to the subject of comets, Martin Stuart observed this publication reporting that Comet Lovejoy "won't return to the solar system for 8000 years" (17 January, p 7). He understands "the solar system" to mean "the sun and everything orbiting it, including comets".

So: "Where is it going? How does it get back again?" And, crucially, "who is helping it with the orbital dynamics?"

Obviously, Martin surmises, the answer is "aliens". But "how did they let this story get out?"

FINALLY, the answer to the solar-system conundrum above may be supplied by Gáspár Bakos. Marc Smith-Evans notes that, according to a reputable weekly science



magazine, this researcher "has published findings on 56 planets" (10 January, p 8). The impression was thereby given that Bakos had not only found Earth-like planets, but had located publishing houses on them – a more significant first for Princeton University's research impact ratings than the piece made explicit.

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Right Q

I use predictive text on my cellphone. When I type the letter "q" I get suggestions, all of which start with "qu". When I then press "u", I get different suggestions. Why? I realise it's quite trivial, but I'd still love to know the answer.

When you type the letter "q", some words are suggested by the phone. If one of these words was the word you wanted to type, then the phone would expect you to select that word from the list rather than keep typing.

So, when you follow by pressing the letter "u", the phone assumes that the word you are typing hasn't yet appeared in the list, and so it suggests some different words.

*Catriona Quin
Dunblane, Perthshire, UK*

Trail of mystery

In my grandmother's house a snail-trail-like substance is visible on the mat in the conservatory each morning. There are no apparent signs of a snail living in the room and the door is locked at night. Is there another insect or animal that causes this effect?

The snail-trail-like substance is indeed caused by a snail-like-creature, but one without a shell – the slug.

Having recently been on a course run by the National Museum of Wales, I have begun to appreciate the subtleties of a

slug's life. It is more than likely that the slug is living in your grandmother's house under a skirting board or cupboard, having probably entered attached to someone's shoe.

In light it will immediately seek darkness and only appear at night. The slug, or slugs, will be delighted if there is a plate of dog or cat food close by.

The slime trail that the slug leaves is one of its greatest defences because most animals, including humans, don't like touching them and so leave the creatures alone. However, it is also a weakness because it reveals that the slugs have been present.

There are many different species of slugs found in the UK and the 2014 book *Slugs of Britain and Ireland* allows you to identify any slugs you may find and discover whether they are a garden pest (as many keen gardeners would have you believe) or helpful, for example with composting. I am saving my copy for when my grandchildren next visit so that we can all go on a slug hunt and discover how many species I have in my garden – or my house.

*Gillian Coates
Trefor, Anglesey, UK*

Filtered water

As a photographer, I have always wondered why the light reflecting off water, foliage and glass is affected by polarising filters, but the light reflecting off metal surfaces is not.

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The fundamental reason for the difference is the way the free electrons in the metal interact with light waves. The key to understanding this is Fresnel's equations, which describe

"Fresnel's equations describe how much light is reflected by a material using its refractive index"

how much light is reflected by a material based on its refractive index.

These calculations depend on the polarisation of light in two planes: perpendicular to the plane of incidence ("s") and parallel to it ("p"). The equations predict that at a particular angle, known as Brewster's angle, the amount of "p" polarised light will fall to a minimum.

For glass, transparent plastics and water the refractive index is between 1.33 and 1.6. This leads to a Brewster's angle of between 50 and 60 degrees, causing the "p" reflectivity to drop to zero. So if your filter blocks the "s" wave, you will see no reflection at all.

For metals, it's more complicated. The refractive index becomes a "complex" number, with real and imaginary parts. The imaginary part describes how strongly the metal absorbs light and is a very large number.

When plugged in to Fresnel's equations, this also makes the Brewster's angle large, up to around 85 degrees. The reflection of the "p" polarisation only dips a little, maybe to 74 per cent,

so the filter wouldn't produce a strong contrast.

Foliage, of course, is a complex mix of materials. It contains a lot of water, doesn't have many free electrons, but it does absorb light. Its refractive index isn't easy to calculate, but will be between that of water and a metal. It would have a significant imaginary part to the index, but much smaller than for a metal. So one would expect the effect of the filter to be weaker on leaves.

*Harvey Rutt
Southampton, UK*

This week's questions

GLASS TAPS

I couldn't get the ground-glass stopper out of a decanter of brandy, until a few taps from a wooden spoon on the neck of the bottle freed it. How does this work?

*Trevor Jones
Cheveley, Cambridgeshire, UK*

LIVING IN THE PAST

The number of my direct ancestors alive at any given time increases the further back you go. However, eventually that number is reduced to the handful who were the putative ancestral Eve and Adam, around 200 million years ago. When was the number of my direct ancestors that were alive together greatest, and how many were there?

*Katka Kessler
Letchworth, Hertfordshire, UK*

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